METAL PROGRESS

Vol. 41 January, 1942 No. 1

# Table of contents

# METAL PROGRESS

Published by The American Society for Metals
Volume 41; January to June, 1942


# SHELL STEEL MANUFACTURE


By Charles M. Lichy
Assistant Metallurgist
Pittsburgh Works
Jones & Laughlin Steel Corp.


*TWO YEARS AGO* or even just one year ago, steel plant operators were worrying about hardenability, front fenders, and free machining steels. Today the mill lingo is turned into one of defense and attack, and the most talked about subject is shell steel.

As has been so appropriately stated, good shells must be made from good steel. It follows that good steel starts with the careful selection of good raw materials. You can make bad steel from good raw materials, but you can't make good steel from poor iron. At Jones & Laughlin, and I believe this to be true of other companies, careful attention is given to the most minute detail of preparation of all materials going into the production of steel. The coal is selected, washed, and mixed in the correct combination as mined from the various fields to produce coke with the best structure, with a minimum of ash and sulphur. Limestone is selected for a high basicity and a minimum amount of silica and sulphur. These are charged into the blast furnace with selected and mixed ores to produce a high quality iron, also with a minimum of sulphur.

The shell steel grade, as supplied during the closing months of 1941, conforms to U. S. Army Specification 57-107-D and U. S. Navy Specification OS-1231. While two grades have been involved, by far the greatest majority of steel has been furnished in the resulphurized grades WDX-1335-40-45 with chemistry as follows:

Carbon, 0.30 to 0.50%
Manganese, 1.35 to 1.65%
Phosphorus, 0.050% max.
Sulphur, 0.075 to 0.150%
Silicon, 0.15 to 0.30%

The manufacture of shell steel may vary according to the locality, mill setup, availability of raw materials, economics involved in various processes, and the type of equipment existing. While I will deal mostly in generalities, I will outline a typical example of its manufacture in the Pittsburgh district.

The steel is being produced by the basic openhearth process, using a combination of

scrap and pig iron charged on top of limestone calculated to a 3.5 to 4% CaO content. A typical basic charge at the present time is 55 to 57% scrap with the balance or 45 to 43% of the charge usually made up of molten, high manganese, basic pig iron with approximately 1.80 to 2.00% manganese. The melt down carbon is over 0.60%, usually between 0.80 to 0.90%, and the heat is often worked with ore and burnt lime to approximately 0.20% carbon. Common practice is to add no ore after the bath has reached 0.45% carbon; however the additions are calculated to work the steel down to 0.20% carbon.

Careful attention is given the slag composition throughout the refining of the heat, and a good condition should show between 13 to 16% FeO, not less than 6% $Fe_2O_3$, with a "V" ratio of 2.6 to 3.0 of available CaO to $SiO_2$. The slag is thickened by additions of burnt lime just prior to charging the furnace deoxidizers, in order to decrease the rate of transfer of FeO from the slag to the bath, and also to prevent phosphorus reversion.

Heats are worked from approximately 0.80% carbon to 0.20% carbon where they are blocked with 11% ferrosilicon and silico-spiegel (a ferro-alloy containing 20% manganese and 4% silicon), or with 15% ferrosilicon alone. From 80 to 100% of the ferromanganese necessary for the specification is added to the bath at this time. Fifteen to 20 min. after the block, the heat is tapped at a temperature of approximately 2925° F.

## Ladle Additions

Ladle additions consist of sufficient 50% ferrosilicon and sulphur to meet the chemical specifications; also the rest of the manganese. Ferrotitanium or small amounts of aluminum might also be added in the ladle to further deoxidize and cleanse the heat. Generally speaking, shell steel or X-1335 analysis has been produced in both coarse and fine grain, depending again upon the manufacturer. With the present shortage and trend in the industry to conserve aluminum, many manufacturers are reverting to practices that make steel with coarse grain. Our practice is to use a minimum amount of deoxidizer (usually small amounts of ferrotitanium or aluminum) in order to keep machinability at a maximum. We prefer not to even use any silicon, but recently the "D revision" of the shell steel specification has added 0.15 to 0.30% silicon to the analysis. Attempts are being made to have this silicon specification removed, except in those cases where added strength may make it necessary.

After the ladle is held for approximately 15 min. to allow the products of deoxidation to rise into the slag, the steel is teemed through a 1½-in. nozzle at a temperature of 2800° F. into 24×26×65-in. big-end-up molds with either Charman and Darlington permanent hot tops or standard brick hot tops. Ingots are allowed to stand at the platform 1½ hr.

The ingots are then stripped from the cast iron mold and charged upright into soaking pits. A pit is usually charged with four to ten ingots, depending on the size of the pit; it is heated to 2400° F. and the steel ingots are allowed to remain in that temperature for 5 to 6 hr., or until they are thoroughly heated to the desired temperature throughout their full cross-section.

The properly heated ingots are rolled to the appropriate bloom size on a 44-in., two-high reversing blooming mill, with 1 to 1½-in. drafts. The 8×8-in. bloom is rolled in 24 passes with six 90° turns, while a 7×7-in. bloom is rolled in 26, and a 6×6 in. in 28 passes with 7 turns. Blooms are finished at approximately 2050° F. and sheared to the proper mill lengths.

Large size blooms, 8×8 in. and over, are immediately loaded into gondola cars at a temperature of 1600° F., covered with granulated slag and slowly cooled to a temperature of 500° F.; cooling time is in the neighborhood of 60 hr. The 7×7-in., 6×6-in., and smaller billets are also immediately cleaned off the hot beds and loaded into cars in large lifts, but are not usually covered.

The examples noted above are for those mills that are double converting, or rolling to an intermediate bloom size, reconditioning, reheating, and rolling to the finished bar size. There are a number of mills that are rolling such sizes as 4×4-in. billets direct from the ingot in one heating on a three high blooming mill, or even in a continuous billet or rail mill.

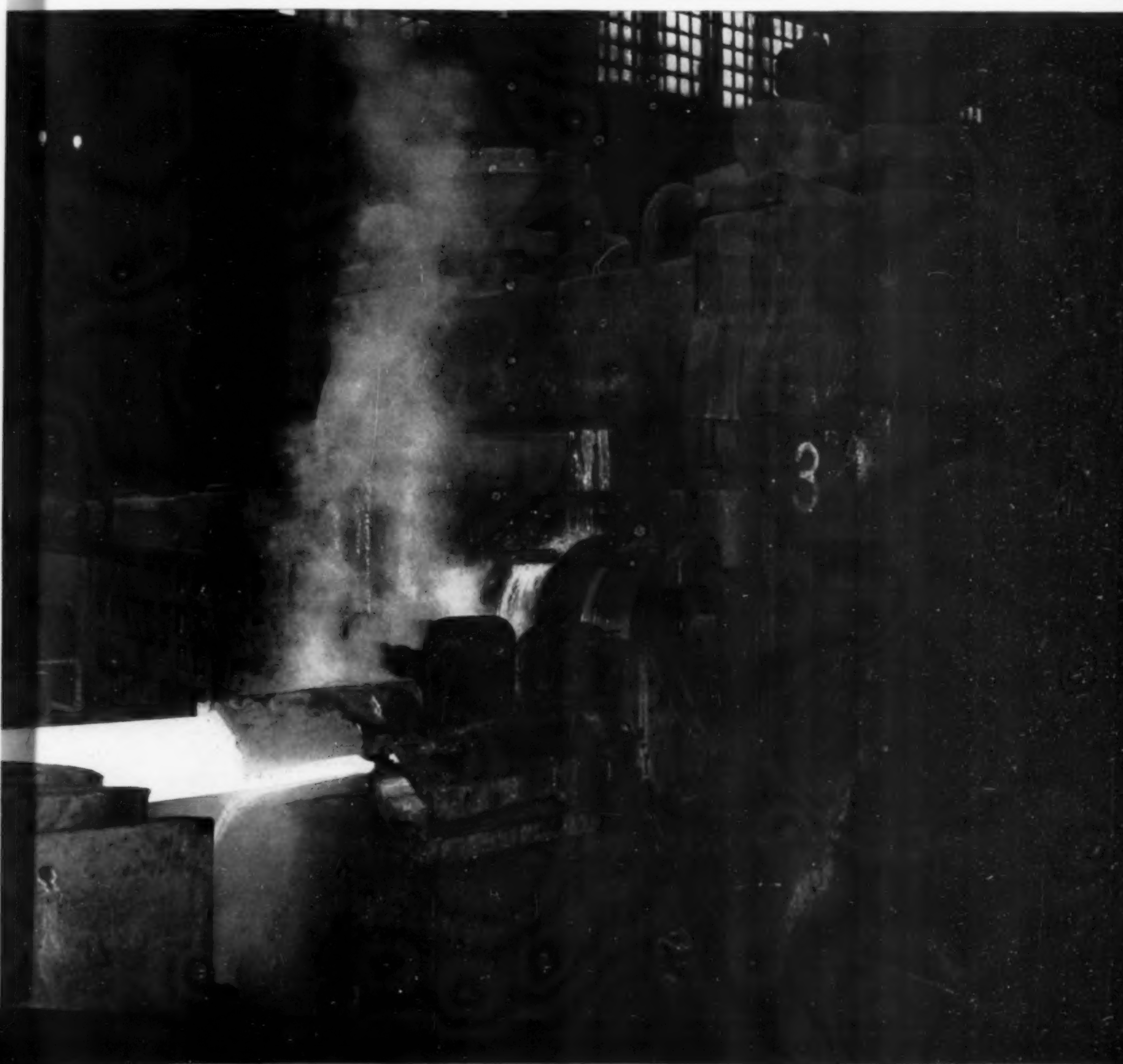
All of the ingots in the blooming mill are identified according to the position in which they were teemed at the openhearth, and all finished blooms are further identified according to their position in the respective ingot. Etch tests are then cut from the top and bottom blooms from the first, middle, and last ingot, prepared and submitted to the local U. S. Army Ordnance Inspector. Drillings for check anal-

ysis are also submitted from these identified blooms.

After the etch tests have been accepted by the ordnance inspector, the blooms are reconditioned by either flame scarfing or hammer chipping in order to remove all injurious surface defects. The reconditioned blooms are then charged into reheating furnaces and rolled into the ordered billet or bar size. The 8×8-in. bloom is rolled on a three high, three stand, 30-in. mill into a 4×4-in. square billet. The 7×7-in. and 6×6-in. blooms are rolled on a 12 stand, cross country 14-in. merchant mill to 2½ to 3$\frac{3}{32}$-in. rounds or round cornered squares. Bars are sheared to customer's ordered lengths, inspected by the Army Ordnance Inspector and shipped to destination.

In conclusion, I might state that the manufacture of shell steel is under strict metallurgical control with metallurgical inspectors placed at all strategic points starting at the blast furnace. They have the authority to de-grade a heat of steel at any unit on which malpractice is observed. By this exacting procedure of carefully selecting raw materials and following a closely controlled method of steel manufacturing and rolling practice, the steel manufacturer feels that a quality of shell steel is being produced in this country today that is better than ever before made.

*Bloom Surfaces Are Cleaned With Flame Scarfing or by Chipping Hammer, Then Reheated and Rolled to Ordered Size*



# TERMS USED IN

# POWDER METALLURGY

**"Powder Metallurgy is the art of producing metal powders and shaped objects from individual, mixed, or alloyed metal powders, with or without the inclusion of non-metallic constituents, by pressing or forming objects which are simultaneously or subsequently heated to produce a coalesced, sintered, alloyed, brazed, or welded mass, characterized by the absence of fusion, or the fusion of a minor component only."**

*BECAUSE* of the growing importance of powder metallurgy and the great interest in this subject shown by members of the American Society for Metals from the metallurgical, application and economical aspects, the ASM Metals Handbook Committee organized a subcommittee of experts to prepare a glossary of terms.

The glossary that follows is to be a part of the chapter on powder metallurgy in the next edition of Metals Handbook and should provide a much needed set of definitions to unify the terms used among ASMembers as well as in the industries, government departments and universities, and by writers of technical literature. The glossary was prepared by a subcommittee under chairmanship of CHARLES HARDY. Its members included C. W. BALKE of Fansteel Metallurgical Corp., R. P. KOEHRING of Moraine Products Division, General Motors Corp., L. L. WYMAN of General Electric Co., and J. EDWARD DONNELLAN of the national office, ASM, who acted as Secretary.

**Acicular** — See needles.

**Air Separation** — The classification of metal powders into particle size ranges by means of a controlled air stream.

**Apparent Density** — The weight of a unit volume of powder, usually expressed as grams per cc. or grams per cu.in., determined by a specified method of loading.

**Arborescent** — See dendritic.

**Atomization** — The dispersion of a molten metal by gas or liquid pressure into small particles which solidify upon cooling.

**Binder** — A cementing medium.

**Blank** — A pressed, pre-sintered, shaped, cut or sintered compact of powdered metal, usually in the unfinished condition.

**Blending** — See mixing.

**Bridging** — The formation of arched cavities in a powder mass which results in voids in the sintered compact.

**Briquette** — (Synonymous with **Compact**.)

**Cake** — A mass of weakly coalesced metal powder resulting from the reduction of metal oxides.

**Carbonyl Powder (or Carbonyl Particles)** — A metal powder prepared by the thermal decomposition of metal carbonyl.

**Chemical Deposition** — The replacement or precipitation of one metal from a solution of its salt by the addition of another metal or reagent to the solution.

**Coining** — See sizing.

**Cold Pressing** — The forming of a compact at room temperature.

**Comminution** — See pulverization.

**Compact** — (Synonymous with **Briquette**) — An object produced by the compression of individual, mixed, or alloyed metal powders with or

without the inclusion of non-metallic constituents.

**Compressibility** — The property of a metal powder mass to yield under pressure.

**Compression Ratio** — The ratio of the volume of a loose powder to the volume of the compact after application of a specified pressure.

**Continuous Sintering** — Pre-sintering or sintering in such a manner that the objects are advanced through the furnace at a fixed rate by manual or mechanical means.

**Core Rod** — A member of a die assembly used to produce a hole in a compact.

**Cored Bar** — A compact of bar shape heated by its own electrical resistance to a temperature high enough to melt its center.

**Cut** — That portion of a powder sample which lies between two stated particle sizes or two screen-mesh sizes.

**Dendritic** — Metal powder particles, usually of electrolytic origin, having the typical "pine tree" structure. (Also sometimes called **arborescent**.)

**Density Ratio** — The ratio of the apparent density to the theoretical density of a solid mass of the powder.

**Die** — The part or parts making up the confining form in which a powder is pressed.

**Die Insert** — A replaceable liner for a die.

**Die Set** — The parts of a press that hold and locate the die in proper relation to the punches.

**Disintegration** — See pulverization.

**Dust** — The portion of a powder sample which passes a 325-mesh screen.

**Electrolytic Deposition** — The production of a metal from a solution of its salt by the passage of an electric current.

**Flake** — Flat or scale-like metal powder particles whose thickness is very small compared to the other dimensions.

**Flow Characteristic** — The rate at which a metal powder will flow through an orifice in a standard instrument and/or according to a specified procedure.

**Galling or Seizing** — The impairment of the surface of a compact and/or of the die parts due to friction.

**Granular** — A formation of metal powder particles in approximately equi-dimensional, non-spherical shapes.

**Granulation** — The production of coarse metal particles by pouring the molten metal through a screen into water or by violent agitation of the molten metal while solidifying.

**Growth** — The increase in dimensions of a compact which occurs during the sintering.

**Hot Pressing** — The simultaneous forming and heating of a compact.

**Impregnation** — The process of filling the pores of a sintered compact, usually with a lubricant.

**Intercommunicating Porosity** — That type of porosity in a sintered compact in which the pores are intentionally connected so that a fluid may pass from one to the other or completely through.

**Irregular** — The lack of symmetry or irregularity in metal powder particles.

**Lower Punch** — The lower member of a die assembly which forms the bottom of the die cavity. It may or may not move in relation to the die.

**Lubricating** — Mixing with or incorporating in a powder some agent to facilitate pressing.

**Matrix Metal** — The lower melting point metallic constituent of a powder mixture which melts during the sintering operation and functions as a cementing medium.

**Mesh** — The screen number of the finest screen of a specified standard screen scale through which all of the particles of a powder sample will pass. Frequently, but not necessarily, a part of the sample may pass finer screens.

**Mesh Fraction** — That part of a metal powder passing a specified mesh screen and retained by some finer stated mesh.

**Milling** — The mechanical treatment of metal powder or metal powder mixtures, as in a ball mill, to affect the size or shape of the individual particles, or to coat one component of the mixture with another.

**Minus Mesh or Through** — The portion of a powder sample which passes through a stated screen. (See plus mesh.)

**Mixing** — The thorough intermingling of particles of two or more powders. (Same as **blending**.)

**Needles** — Metal powder particles of elongated form resembling a needle. (A needle-like structure is called **acicular**.)

**Nib** — A pressed, pre-sintered, shaped, sintered, hot pressed, rough drilled or finished compact. Also: A generic term used for a piece of hard carbide material intended for use as a drawing die.

**Nodular** — The knotted, rounded, or other similar shapes observed in metal powder particles.

**Packing Material** — Any material in which compacts are embedded during the pre-sintering or sintering operation.

**Particle Size** — The controlling lineal dimension of an individual particle as determined by analysis with screens or other suitable instruments.

**Particle Size Distribution** — The percentages expressed in terms of weight of the various sizes of particles in a powder sample when classified in terms of size ranges, and measured in terms of screen mesh or microns.

**Pill Press** — A pharmaceutical pill press adapted to form compacts.

**Plates** — Flat particles of metal powder having appreciable thickness.

**Plus Mesh or Oversize** — The portion of a powder sample retained on a screen of stated size. (See minus mesh.)

**Pore** — A minute cavity in a compact formed either intentionally or unintentionally.

**Porosity** — A multiplicity of pores in a compact, usually distributed uniformly.

**Pore Forming Material** — A substance included in a powder mixture which volatilizes during sintering and thereby produces a desired kind of porosity in the finished compact.

**Powder** — Particles of matter in which the size and characteristics are of such an order as to make the material of use in the formation of compacts.

**Powder Metallurgy** — Powder metallurgy is the art of producing metal powders and shaped objects from individual, mixed, or alloyed metal powders, with or without the inclusion of non-metallic constituents, by pressing or forming objects which are simultaneously or subsequently heated to produce a coalesced, sintered, alloyed, brazed, or welded mass, characterized by the absence of fusion or the fusion of a minor component only.

**Pre-Sintering** — The heating of a compact at a temperature below the normal final sintering temperature, usually to increase the ease of handling or forming the compact or to remove a lubricant or binder prior to sintering.

**Press** — A machine used to form a compact by pressure.

**Pressed Bar** — A compact in the form of a bar.

**Pressed Density** — The weight of a unit volume of powder which has been pressed into a standard test piece of finished compact at a designated unit pressure.

**Pressing** — The forming of a compact under pressure.

**Pressing Crack** — See slip crack.

**Puffed Bar** — A cored bar expanded by internal gas pressure.

**Pulverization** — The reduction of metal to fine powder by mechanical means. (**Disintegration** and **Comminution** are terms also used.)

**Rate of Oil Flow** — The rate at which oil will pass through a sintered porous compact under specified test conditions.

**Roll Compacting** — The progressive compacting of metal powders by the use of a rolling mill.

**Rolls** — A machine used to apply pressure progressively to form a compact.

**Scale** — The layer of oxide which is formed on metals when heated under oxidizing conditions.

**Segment Die** (or **Split Die**) — A die made of parts which can be separated for the ready removal of the compact.

**Seizing** — See galling.

**Shot** — Metal powder particles of spherical shape, usually solid.

**Shrinkage** — The decrease in the dimensions of a compact which occurs during sintering.

**Sintering** — The heating of metal powders or compacts to convert them into coalesced, alloyed, brazed, or welded masses, under controlled conditions of time, temperature, and atmosphere.

**Sintering Furnace** — A furnace used to heat metal powders or compacts during the pre-sintering or sintering operations. The heating and subsequent cooling may be carried out in a controlled, inert, or reducing atmosphere, or in a vacuum.

**Sizing or Coining** — A final pressing on a sintered compact to get desired size or physical properties.

**Slip Crack** or **Pressing Crack** — A rupture in the pressed compact caused by the mass slippage of a part of the compact.

**Specific Surface** — The surface area of one gram of powder, usually expressed in sq.cm.

**Spherical** — Metal powder particles of spherical shape which may be either solid or porous.

**Split Die** — See segment die.

**Spongy** — A porous condition in metal powder particles usually observed in reduced oxides.

**Sprills** — Metal powder particles of cylindrical form, not much larger than their diameter.

**Stripper Punch** — A punch which, in addition to forming the top or bottom of the die cavity, later moves further into the die to eject the compact.

**Superfines** — The portion of a powder sample which is less than 10 microns in size.

**Sweat Out** — The low melting constituent of a compact which melts during sintering and subsequently appears on its surface.

**Tap Density** — The apparent density of a powder obtained when the volume receptacle is tapped or vibrated during loading.

**Upper Punch** — The member of a die assembly which moves into the die to transmit pressure to the powder contained in the die cavity.

**Void** — An unintentional empty space in a sintered compact.

# CONSERVATION AND SUBSTITUTION IN CR-NI-FE ALLOYS

Three of the Discussions at the
National Defense Meeting on
Stainless Steel
Philadelphia, Oct. 21, 1941

## Utilization of Stainless Scrap

By Hubert A. Grove
Metallurgist, Alloy Steel Division
Republic Steel Corp.
Massillon, Ohio

*THESE REMARKS*, presented to the National Defense Group Meeting of the ⊕ National Convention, should be interpreted as an effort to show how available scrap metal affects the conservation of raw materials required for the manufacture of necessary corrosion resistant steels. Attention will be confined to the wrought forms, principally stainless steel sheet, strip and thin plate. Owing to the flawless surfaces demanded for most uses a larger proportion of plant and mill scrap is produced than in other steel specifications. The critical requirements as to low carbon content (if the material is to be welded) also sharply limit the re-use of scrap material, even though it already has acceptable chemical composition.

The use of stainless scrap in the making of stainless steel and the efficiency with which it may be employed is somewhat debatable. This controversy covers not only the *recovery* of such metals as nickel and chromium, but the *workability* and *ductility* of stainless steels made from all-scrap or high-scrap melts. The figures which follow in this discussion are rough approximations, and are used merely to illustrate certain facts regarding stainless scrap and its use in the making of stainless steel.

Last year, approximately 250,000 tons of stainless ingots were produced by the steel industry in America. Of this amount, about 150,000 tons went to the trade and the balance or 100,000 tons became mill scrap. Thus we count on about 40% mill scrap, whereas 30% is a generous figure for mill scrap in the tonnage steels.

The 100,000 tons of scrap is not all recoverable scrap because approximately 13% has been lost through scale, grinding dust and pickling liquors, which leaves about 87,000 tons of metal capable of remelting. The chromium-nickel grades make up approximately 52,000 tons of this amount, and the balance or 35,000 tons is of the straight chromium type stainless.

To this scrap volume must also be added the scrap resulting from the fabrication of trade products. This may vary, plant to plant, from a few per cent to as high as 50%. If 20% is taken as a conservative figure, the resulting amount is 30,000 tons of trade or new plant scrap. Of this tonnage, only about 50% or

15,000 tons may find its way back to the steel mills in such form that it can be re-used for its alloy content. Using the same balance of chromium-nickel to chromium stainless types, we have 9000 tons and 6000 respectively, which, when added to the mill scrap, gives us 61,000 tons of chromium-nickel scrap and 41,000 tons of straight chromium stainless available for remelting. Through the entire industry, therefore, the trade scrap about balances the steel mill losses, and we have the problem of handling about 100,000 tons of scrap when we make 250,000 tons of ingot — a 40% circulating load.

Remelting of this scrap to recover the alloys contained in it in the most efficient manner is the next problem which presents itself. The two types of electric furnaces used for this purpose are the arc furnace and the induction.

The latter can be charged with 100% of scrap and very little loss of alloy is encountered. In induction melting, there is no pick-up of carbon; however, incidental impurities of phosphorus or sulphur will not be removed. The capacity of these furnaces is small and but few of them are in use for this purpose by the steel companies. The quality of induction steel, as far as the chromium-nickel grades are concerned, appears to be comparable to the quality of arc-furnace steel in their forming characteristics and corrosion resistance.

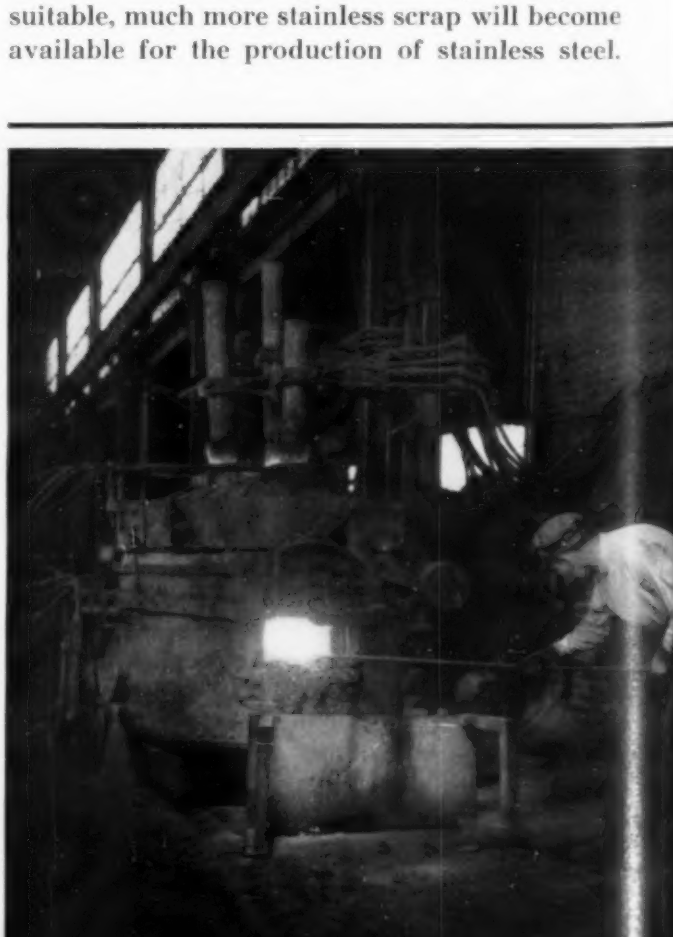
As for the straight chromium types, principally the 16 to 18% variety, induction-furnace steel appears to have a tendency to harden slightly more than arc-furnace steel, and this may give trouble with cracked slabs. At least this has been our experience, although others may disagree.

In the remelting of scrap in the arc furnace, various amounts can be charged. For the low carbon grades, stainless scrap charges are generally kept around 10% of the total, but for the higher carbon grades considerably larger scrap charges may be employed. However, the continual use of high scrap charges will result in a carbon pick-up, which will in time exceed 0.12%, the limit of most steel specifications. The carbon can be worked down in high scrap heats, but this results in the loss of chromium in amounts which are objectionable. Therefore, the only alternative is to use less scrap and add virgin nickel and chromium to keep the carbon under or around 0.12%. In other words, 10% of scrap can be easily used, but we have 40% to remelt.

Fully annealed high carbon (0.15% max.) chromium-nickel grades, when not used in welded construction, are as corrosion resistant to most surroundings as the low carbon varieties. For welded construction, where severe corrosive conditions are encountered, the carbon must be kept under 0.08% when the steel is not stabilized, but when titanium or columbium is present as a stabilizing element, the carbon can generally run to 0.10% max. and the steel will meet all the requirements of embrittlement tests usually imposed on these grades.

While every effort is being made (*must* be made) to use larger percentages of scrap to conserve nickel and chromium, the majority of the Army, Navy and aircraft requirements are for weldable grades for which the armed services require either stabilized low carbon material or low carbon 18-8 steels. These specifications limit the amount of scrap that can be used in making up the furnace charges, and until such time as such specifications can be modified, the amount of scrap that can be utilized in remelting will be small. Such a situation is not healthy, for it builds up large tonnages of inactive scrap, wherein quantities of valuable nickel and chromium are immobilized. However, if carbon can be permitted to go up to 0.12%, much larger amounts of scrap can be remelted.

It may be of interest to know that action is now being taken by certain departments in the Government to modify their specifications so as to include the higher carbon grades. When these are used in such places as they clearly are suitable, much more stainless scrap will become available for the production of stainless steel.



# True Economy in the Use of Chromium and Nickel

By Matthew A. Hunter
Professor of Metallurgical Engineering
Rensselaer Polytechnic Institute
Troy, N. Y.

*THE QUESTION* of conservation, the general topic of the National Defense Group Meetings of the ⊕ Convention, is a matter of direct concern to all consumers of heat resistant alloys. It has been discussed also by many of our technical groups. Since the Driver-Harris Company, which the writer serves as consultant, is regularly making the grades of nickel alloy castings with trade designations NC-I, NC-II, NC-III, NC-IV and CN-36 in substantial quantities, it too is deeply interested.

I take it that the common aim of all of us is to help speed up production and obtain the maximum output of essential materials for every pound of nickel used. With this in mind, I have read with a high degree of interest, yet with some concern, the report of the Alloy Casting Institute on the conservation of nickel in heat resistant alloy castings. This was a well considered document entitled "Conservation of Nickel in Alloy Castings" and was submitted to LeRoy Whitney, then chief of the Metals Priority Division of the Office of Production Management.

By way of introducing the present discussion the following information is taken from that report: In 1940, about 2,000,000 lb. of castings of the 60% nickel grade were made, and about 4,000,000 lb. of castings of the 35% nickel grade. In the interests of nickel conservation, it was suggested that 75% of the castings in *any* nickel grade be transferred to a lower grade in production. This would have meant the production of only 500,000 lb. of castings in the 60% grade instead of 2,000,000; in the 35% grade, 3,000,000 lb. instead of the 4,000,000 lb. actually produced; in lower nickel, higher chromium grades, a corresponding increase, since they are augmented by degraded 35% nickel castings. The nickel actually consumed in all grades of castings in 1940 was 3,400,000 lb. The proposed substitution would have saved 1,000,000 lb. of nickel but consumed an additional 500,000 lb. of chromium.

*-Off, Preparatory to Pouring a Heat of hromium-Nickel Alloy Into Heat Resistant at Plant of Electro Alloys Co., Elyria, Ohio*

Let us examine this proposal on the basis of utility of product, rather than immediate conservation of nickel and chromium, for a rapid change in international affairs may easily reverse the situation as it was seen in mid-1941; in other words the slowly expanding nickel supply from our near neighbor Canada may easily become less critical than the chromium, largely brought in over long sea lanes.

Committee B-4 of the American Society for Testing Materials, in a report on the situation, recognizes that conditions are so severe in some equipment as to require alloys having a high nickel content, and that in such situations the use of the 60% nickel alloy casting should be continued. I have not seen any estimate as to whether the 500,000 lb. of 60% alloy in the allotment proposed by the Alloy Casting Institute will be sufficient to meet the requirements for the severe conditions just mentioned. Such a survey should certainly be made before adopting a 75% (or any definite percentage) reduction in high nickel alloy castings.

I want, however, to bring before you at this time some technical facts which should be considered by those who will be responsible for the policies to be finally adopted.

The first point I would like to emphasize is that all customers using nickel alloys are presumed to have competent metallurgists and economists in their employ who are well aware of the technical angles of their problems. When they are satisfied that economy results from the use of a higher nickel content in an alloy casting, such castings are recommended. The main factors which enter into their calculation are:

1. The first cost of the casting.
2. Heat-hour cost, or the life of the casting.
3. The loss or gain in production due to more or to less frequent changes in casting.
4. The time consumed in machining operations necessary to installation.

The most important of these items from the point of view of the conservation of nickel (or chromium) is the second one — the useful life

of a casting. If a situation exists — and there are many of them — where a 60% nickel alloy casting will give approximately three times the life in hours that a 35% nickel alloy casting will, then its adoption results in a considerable saving in nickel. By way of example, a 1000-lb. retort made of the 60% alloy will contain 600 lb. of nickel and 150 lb. of chromium and may last, depending on operating conditions, for from 5000 to 10,000 hr. To maintain a 1000-lb. retort of 35% nickel under identical conditions will require three castings containing 1050 lb. of nickel and 510 lb. of chromium. If during this period one of these retorts were returned as scrap for remelting, this would reduce the amount of nickel to be used to 700 lb. and chromium to 340 lb. In the remelting operation, a further quantity of at least 100 lb. of nickel and 60 lb. of chromium would have to be supplied to compensate for losses of metal in service and in remelting. This would require a total of 800 lb. of nickel and 400 lb. of chromium merely to maintain the 35% Ni retort in service as compared with the 600 lb. nickel and 150 lb. chromium for the single 60% Ni casting. Substitution of a lower grade of nickel would in such cases result in a larger consumption of alloys per unit of production, or a lowered total production — and probably both.

I have not taken this three-to-one ratio out of thin air. The comments of one manufacturer using many heat treating furnaces is typical of many which we have received: "If we were to use 35% nickel in retorts in electric rotary carburizing furnaces as well as in gas heated units, we would expect to use three times the number of retort castings in the same time that one 60% casting would last. We use 35% nickel alloys wherever possible and have numerous installations. But where the retort is subject to continual changes in temperature due to contact with cold load and subsequent reheating, the lower nickel content does not give economical life. Pit type furnace retorts are made of the higher alloy. In pusher type furnaces we use high nickel content at the feed end, whereas that portion of the retort where the work is at heat has always been 35%. The 60% nickel alloy in rotary containers softens and bends at a temperature several hundred degrees higher than the 35% alloy. The common practice is to load 600 lb. of steel parts in the smaller and 1200 lb. in the larger retorts. Under such loading the 35% nickel container would not hold its shape for any reasonable length of time."

It will be noted that this user is putting various alloys in those places where he believes the maximum economy will result. That should be our prime object. There is no disposition to decry the excellent properties of such alloys as 25% chromium, 12% nickel; merely to indicate that it would be a disservice to them to place them in duty they could not well perform.

A second manufacturer writes "The 60% nickel alloy is most efficient and economical for gas carburizing retorts. We can use 35-12 and 12-25 but the life will be only one-third that of 60-12."

A third producer indicates that "35-15 failed after 150 to 500 hr. of service and 60-14 was shut down after 2000 to 5000 hr. Hearth plates of 35-15 in annealing furnaces cracked in less than 150 hr. and were replaced by 60-15, which have given two years of continuous service."

I could multiply these experiences many fold from communications which have been received. These are sufficient, however, to indicate that under the operating conditions prevailing in these plants there are situations where the 60% alloy *does* result in a real economy, and if the relative life approaches three times that of a lower nickel grade the use of the higher grade will result in conservation of nickel and chromium.

The other factors which I mentioned as entering into consideration are the loss in production due to more frequent changes which follow the use of castings of shorter life and the time consumed in machining operations which are incidental to their installation. When a change in a retort means a shutdown of 40 hr. in production and machining time of from 20 to 60 hr. with the interruption of time schedules which ensues, the loss in production can become considerable.

For these reasons distinct advantages can be claimed for the 60% nickel alloy casting:

1. Where the castings involve the application of considerable expense and machine work, or

2. Should castings involve a considerable expenditure of time and money to get at and replace in the event of failure.

In quenching fixtures whose failure in use might ruin considerable quantities of valuable partially finished material, its use is again indicated.

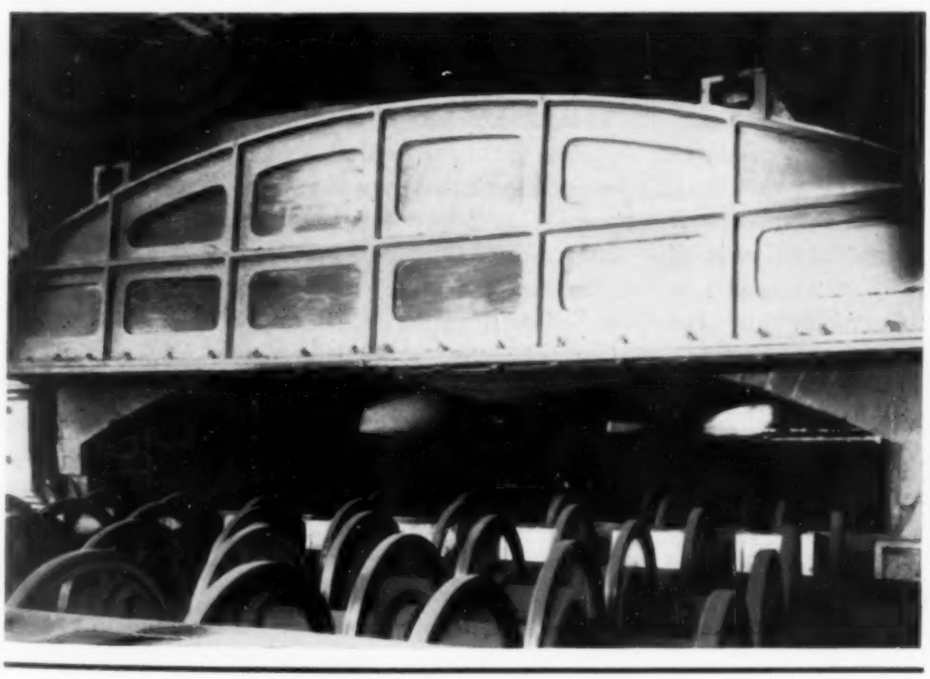
Another factor which must be considered is that additional melting and foundry capacity will be necessary if lower analyses are adopted with their more frequent replacements.

And finally, but not the least in importance, comes the fact that many present day designs are based on higher nickel alloys. A reduction at this time would involve serious handicaps due to delays necessary for redesigning to accommodate the physical properties of the lower alloys.

All of these things are known to the metallurgical staffs of the operating companies who use heat resistant castings. At their insistence, several of the more prominent alloy foundries (including Driver-Harris Co.) make both high and low alloys for different applications, sometimes even for different parts of the same application. All responsible customers know the alloy which fits best into their production or disturbs it least.

These, then, are some of the compelling reasons why an arbitrary reduction in the use of the 60% nickel alloy casting should not be made. That *some* reduction could be made is undoubtedly true. The extent of that reduction can be determined only after making a more intensive survey of the situation than appears yet to have been made. If an arbitrary cut in production of 60% nickel castings from 2,000,000 to 500,000 lb. had been made in 1940, it would probably have resulted in a greater consumption of nickel and chromium to maintain industrial production at its actual level.

*Roller Hearth in Large Annealing Furnace, Made by Surface Combustion Corp. for Slabs, Plate, or Long Thin Work on Flat Trays*



## Stainless Clad Steels

By Samuel L. Hoyt
Technical Advisor
Battelle Memorial Institute
Columbus, Ohio

*STAINLESS CLAD* steels have been substituted for solid stainless primarily for economic reasons. As a typical case consider a large vessel for the processing industries; if made of solid stainless steel it might impose too great a financial burden on the process and usually could be more cheaply built of stainless clad steel or of some other material. The use of a relatively thin layer of stainless on a cheaper common steel backing has been very advantageous for large size equipment and particularly for service which involves high pressures, elevated temperatures, fluctuating temperatures and the like. Due to these advantages, it has been feasible to make and use hundreds of large units for the processing industries. In possibly less spectacular fashion, stainless clad steel has also been used in many smaller sized units, particularly in the dairy and food industries. Finally there are many applications of flat rolled stock such as small stampings, containers, table tops, and architectural trim.

The advantages of cladding are not economic alone. For example, a stainless clad frying pan has a better thermal conductivity than one of solid stainless. As another example, small parts made by deep drawing have shown that stainless clad steel draws better than either of the components alone.

These incentives have led to the use of an appreciable tonnage of clad steel in the past ten years, and the product is now to be rated as a standard commodity, available from several reliable sources. Considerable experience has been gained in its manufacture, fabrication and in service and there seems to be no reason why it should not reach a broad market.

In this connection there are natural limitations which hold for normal times. As the thickness of the composite and the per cent cladding decrease, the difficulties in manufacture and fabrication increase, and the reliability in service decreases, until solid stainless becomes more economical. In thicknesses greater than 1 in., cladding or lining is almost without question more economical than solid stainless, while at some thickness below 0.5 in. the reverse is usually true.

An arbitrary limit cannot be set since the economics of an application depend on a variety of factors. If the per cent cladding is reduced from the more or less standard 20% in order to save costs, the surface layer is apt to be too thin for handling, and may even be too thin for service where chemical attack or erosion is a factor. While 10% cladding can be used for the heavy gages, 30% cladding may be required for the light gages. Obviously, considerable experience is needed in choosing the product for new applications.

Before considering the question of conservation of the critical metals, chromium and nickel, it will be well to discuss the individual clad products or typical methods of cladding.

There are at present five methods which have survived development and commercial exploitation. These are described irrespective of historical development or relative merits.

One producer assembles two plates of stainless with a protective film in between, and seal-welds around the edges. This composite is positioned in a mold and soft steel is cast around it to produce an ingot. This ingot is rolled to twice the final thickness, sheared around the stainless inserts and the two stainless clad sheets stripped apart. The casting and rolling operations weld the stainless to the mild steel back.

Another producer places two such sheets face to face with a protective film in between, and electroplates them with iron, places the composite between two mild steel plates, seals and welds around the edges. Upon heating and rolling the stainless is welded to the mild steel back through the soft electrodeposited iron. The composite is rolled, trimmed, and two clad sheets are produced.

A third producer fuses on a surface layer of stainless to a mild steel backing, by a welding process that does not permit a brief description. The space between a mild steel slab and a refractory mold wall is filled with fused stainless steel by arc melting. The stainless layer fuses onto the mild steel. The composite plate is then rolled and trimmed. (Apparently other methods of arc welding or fusing stainless onto mild steel have been tried and rejected.)

Two other producers rely on spot welding to join common steel to stainless. The first one spaces the spot welds on centers whose positions are designed to give the optimum results. In character of attachment this is the major difference between this method and all others which, it will be recalled, are continuously or homogeneously bonded. The other producer of spot welded liners applies two thinner layers of stainless and an intermediate layer of pure nickel, but overlaps the spot welds to give continuous bonding.

The integrity of the bond is usually of considerable significance and the manufacturers have developed bond tests for their products. It is believed that the so-called "tap test" is probably the best inspection test for the continuously bonded plates. In the case of separated spot welds, hydraulic pressure is applied between the stainless liner and the steel backing.

While the details will vary, the clad plates are fabricated into usable equipment with about the same general technique as used for homogeneous metal.

The composition of the stainless steel used is not critical; this means that cladding or lining can be chosen for the intended use and processed and fabricated to put it in the correct condition of structure and surface finish. Sheets and plates have been the principal clad products. Strip, tubing, bars and shapes have been worked on but these are not important as yet. Clad or lined structures are recognized by Code and other authorities.

Coming to the question of conservation of alloys, it is obvious that the use of a thin liner or cladding conserves stainless steel. This has extended the use of stainless steel into otherwise uneconomic fields. Under our present restricted conditions, the cladding or lining process could be even more widely used as a conservation measure. Looked at another way, a given amount of stainless or of nickel and

chromium could be made to perform several times as much service without sacrifice of inherent corrosion resistance. This extra covering power is sufficiently high to warrant serious consideration; particularly if important uses of stainless are now being met by less satisfactory substitutes. Possibly we could apply stainless more widely for peace uses and still conserve for defense purposes.

The mechanism for extending the use of stainless clad steel might be set up by a priority regulation. For heavy work the situation should be easily handled since the economics are all in favor of cladding. In light gages, provision would have to be made for considerable discretionary power. After all, stainless steel performs very important services and each installation should be carefully examined by experts in the field before deciding that cladding is to be substituted for solid stainless steel.

According to *The Iron Age* figures for consumption of stainless steel in 1940 (issue of July 17, 1941) and using round numbers, 4500 tons went into "plates and shapes not further classified". Of the plate tonnage, possibly a large portion could be converted to cladding with a saving of 80%. The more attractive field, because a much larger tonnage is represented, is that of sheets and strip, of which there were 53,000 tons of 18-8 and 23,000 tons of 17% chromium-iron used. Of course some of these products went into cladding but nevertheless the approximate total amount of nickel used was 8,400,000 lb. and of chromium was 26,800,000 lb. As a maximum figure, 80% of those amounts of nickel and chromium not now used in cladding could be conserved by substituting stainless clad steel for solid stainless.

This situation develops a technological weakness, however, in that the most promising field for conservation is the most difficult one for servicing satisfactorily by any one of the commercial cladding processes. The two spot welding methods are not used to make light gage sheet with a smooth surface, while the three other methods rely on cladding at an early stage and rolling a large composite to the final thickness. On this account the per cent cladding is increased and the unit costs go up, as the final thickness is lowered. Such cost considerations do not apply in the present emergency, and this means of saving strategic metals should be utilized to the utmost. We are fortunate that a peace time economy is available for war time conservation.

# COPPER STRIP*

By Maurice Cook
and
T. L. Richards

*IT IS POSSIBLE*, as shown in a previous paper in the *Journal* of the Institute of Metals, 1940, page 1, for rolled and annealed copper strip to have:

1. A randomly oriented structure (a "normal" type that will be denoted *N*).

2. After moderate cold reduction a mixture of randomly oriented crystals (Type *N*) and the double-texture structure predominate.

3. After heavy cold reduction and the exhaustion of further possibility of deformation by slip, the crystals break down into minute blocks, and their movements develop a fiber texture which is in reality a double texture bearing a twinned relationship. It is noted as Type *D*.

4. After annealing, a structure composed of a mixture of the double texture Type *D* and a single-texture structure described below. The mixed structure is noted as Type *M*.

5. After heaviest reductions the elements of the double texture are so closely interdependent that they coalesce to form a material containing but a single texture (Type *S*).

Which structure or structures are present and the proportions in which they occur are determined entirely by the rolling and annealing conditions employed in the preparation of the strip. A study has been made by X-ray and microscopic methods of the effect of progressively increasing cold rolling reductions and of subsequent annealing on strips of high conductivity copper. In the experiments, four series of tests were made on strip having structures of the Types *N*, *D*, *M* and *S*, respectively, each in three different grain sizes which will be indicated by a second letter *a*, *b* or *c*. All samples were made from a single 1000-lb. ingot of copper.

The same twin-fiber textures are ultimately developed with increasing rolling reductions in strip possessing all four types of initial structure. The degree of preferred orientation of crystals in the strip developed by the rolling operation, although dependent on *(Continued on page 126)*

*Abstracted from "The Influence of Crystal Structure on the Cold Rolling and Annealing of Copper Strip", *Journal* of the Institute of Metals, London, 1941, Volume 67, p. 203.

# TELEPHONE INDUSTRY SAVES METAL

*Phrases strange* to the ears of the average American have become common in recent months. We hear much of "priorities", of "critical materials", of raw material shortages in what had seemed a land of industrial plenty. Interrupted supplies of things like Italian olive oil and Russian manganese ore had caused us to develop alternative sources of supply; fortunately some far sighted action had enlarged our national reserves of tin, tungsten, rubber, and silk, which come from south-eastern Asia, now under serious threat of interruption.

Enormous though American resources in raw materials may be, few have realized how enormous will be the demands of our armed forces. Only in recent months have supplies been practically denied many firms making non-essential items of civilian consumption. Even as important an industry as the automotive has had its permissible quota reduced again and again, in order that plant, machinery, men and materials be diverted into something more important to win the war.

The communications industry (by that meaning telephone, telegraph and radio) is today in a more favored position than, say, the passenger automobile industry, since many of its functions are closely allied with the war effort, and many of its requirements for new equipment and the maintenance of existing equipment receive high priority rating. For instance, OPM's estimates for future supply and demand of copper places metal for the communications industry with that for transportation and power generation as "secondary war requirements", second only to the copper needed for cartridge brass, condenser tubes for naval and transport vessels, and de-gaussing cables.

Even so, the obligation to conserve the non-ferrous metals is by no means absent. In fact, quite the opposite. Nor is such a thing a new enterprise for the telephone industry. Its remarkable growth has always forced its engineers to consider the question "Can we get enough of this material for our expected needs over the next 10 to 20 years?" Readers of Metal Progress may remember the article by Messrs. Schumacher and Ellis of Bell Telephone Laboratories in November 1939, which described the metallic materials in the telephone system. In a discussion of lead cable sheath it was noted that the very satisfactory 3% tin alloy had to be abandoned in 1912 as an economy measure and because anticipated future demands bade fair to absorb a large portion of the World's supply of tin. The 1% antimony alloy used since then has saved some $25,000,000 in cost of alloying metal (figured on the basis of selling prices actually prevailing in the intervening time), to say nothing of a disruption in all other commercial uses of tin.

Protection against raw material shortages, the source of so many production bottlenecks, is in normal times merely a matter of good industrial housekeeping. Now such protection is as vital to the national defense as production itself, for upon this protection production depends.

Before outlining some of these problems — hoping that the methods of solution will start stimulating thoughts in other harassed minds! — it may be well to note that the "Bell System" is subdivided into definite activities. Bell Tele-

phone Laboratories studies the equipment, designs it, and sets up specifications for materials. Western Electric Co. is responsible for production methods, production itself, and installation. The various telephone companies operate the switchboards, cables and subscriber equipment. Finally Nassau Smelting and Refining Co. reclaims scrap from all these operations and from obsolete plant. Any problem, to be properly solved, must bear in mind the individual requirements of this group, acting as a coordinated unit. Consequently a supervisory inter-company committee has been active since early 1941 to expedite this vital work. It consists of H. S. Osborne, plant engineer of American Telephone and Telegraph Co., D. F. G. Eliot, Western Electric's general purchasing agent, R. L. Jones, director of apparatus development at Bell Telephone Laboratories, and Stanley Bracken, Western Electric's engineer of manufacture.

Bell Laboratories' engineers consider the technical questions involved and pass on the suitability of available materials to replace those on the critical list. Manufacturing Department engineers at all of Western Electric's works review the piece parts affected by the shortage of a given material, consider available supplies, discuss the manufacturing features with Bell Laboratories' engineers and revise manufacturing information after agreement has been reached on the substitute to be used. Representatives of Western's purchasing department immediately place new orders, revise outstanding contracts, and attempt to keep a smooth flow of the new material coming in with a reduced volume of the old. Likewise, the manufacturing departments carry a large part of the responsibility for promptly adapting their operations to the new material and methods of manufacture.

*Steel Replaces Aluminum for the Telephone Dial. Finger wheels are being racked, prior to lacquering, at Hawthorne Works, Western Electric Co.*

## Substitution

In considering the problem of substitution, three main types have been recognized.

Class I includes those materials for which engineers have not as yet been able to find working substitutes, and for which substitution may well prove to be impossible. For instance, there is as yet no known substitute for the zinc electrode in a dry cell. Likewise there is no known commercial substitute for copper conductors; silver is in the same class as far as its electrical conductivity is concerned, but it is so expensive and is so limited in quantity that only minor amounts are available (for use in contact points or surfaces).

Class II includes those materials for which substitutes can be introduced without extensive investigation. As an example, Western Electric and the Bell System are substantially reducing their use of zinc by coating much of their outside plant hardware with lead instead of putting these products through a galvanizing process.

In Class III are cases where substitutes may be found, but further work is necessary to determine whether their use is practicable. The Laboratories are studying the possibilities of

using lead foil for condensers instead of aluminum, of which the Bell System would use 125 tons in 1942. The difficulty is to get the lead foil into the same dimensions as the aluminum and thus avoid redesigning the entire condenser, which might then be too big to fit into the limited amount of space provided in certain assemblies of apparatus.

Development of suitable substitutes begins in Bell Telephone Laboratories. The problem is many-faced, and requires a great variety of skills. First comes the materials engineer, who suggests available materials of suitable properties. Metallurgists or chemists are then consulted. Apparatus designers take hold of the problem, to see if the changes in strength, conductivity or insulation require changes in the form of the part or device. Knowledge of manufacturing methods is essential if recommendations are made to fit existing or slightly modified facilities. In some cases circuit experts may be called on to decide whether any changes will be needed in existing systems. Finally, manufacturing engineers of the Western Electric Co. are responsible for the tool setups, and the actual processes of making and assembling the changed parts. The work of these men constitutes a useful function in the defense program even outside the Bell System, for they cooperate with the Government and various engineering societies in developing simplified practices and otherwise alleviating material shortages.

## Specific Economies

This substitution program has a direct and obvious bearing on the outcome of the defense program. For example, a computation made on Sept. 15, 1941 showed that the expected use of aluminum throughout the Bell System for the next 12 months will be reduced by 2,000,000 lb. The use of nickel will be reduced by 352,000 lb., zinc by 3,500,000, and magnesium almost entirely eliminated.

Western Electric now saves 65 tons of aluminum annually merely by replacing the aluminum in the dial finger wheel with steel, which serves the purpose adequately. Copper has replaced aluminum in bus bars, with an annual saving of an additional 100,000 lb.

A thermo-plastic is to some extent replacing zinc-base die casting for the housing for combined telephone sets. Since the alloy contains about 4% Al and 95% Zn, this is a substitution which releases for other purposes a sizable quantity of vital metals. Of all the combined sets now in manufacture 48% are currently of plastic composition. At this rate the annual saving of zinc alone will amount to 4,800,000 lb.

The above examples are simple problems as compared to the conservation of copper. Wire communications are singularly dependent on this metal; approximately 90% of the Bell System's consumption is in the form of bare or insulated wire and as conductors in cable. The opportunities for substitution of other materials are therefore small. There is, of course, a limited field of application for bare galvanized steel wire in covered locations, and in the interest of conserving copper, the use of steel line wire is being extended despite transmission and cost penalties. The quantitative effect of this measure, unfortunately, cannot be great. Bi-metallic copper-steel conductor offers a means of saving copper, and its use in both line wire and insulated wire is being extended without awaiting the outcome of field trials, which would normally be considered prerequisite.

The above quoted article by Schumacher and Ellis emphasized the enormous amount of research and development that has gone into the modern cable, with its 4250 wires, each large enough but not too large, each properly insulated without waste. Use of such highly engineered cable is in itself a major conservation measure.

Another development of outstanding importance in the conservation of copper is the rapid application of different types of carrier systems to toll lines, the existing lines being altered to permit their application, and new routes designed to yield maximum copper savings. This can be accomplished because high frequency carrier systems, including the new broad-band systems, provide 12 or more channels per metallic circuit.

Lacking a sufficient quantity of copper to meet normal requirements, a number of other measures of conservation are being relied upon. All of the following involve definite penalties, not only in cost of installation but in quality of service.

1. In planning cable additions, requirements are being kept at a minimum, and the size of both the cable and conductors is being specified smaller than the economics call for. These sizes meet immediate and near future service demands, but will involve the penalty of requiring relief in the future at a date much

earlier than the optimum size would require. This practice of planning for periods shorter than economically proper is being applied to both exchange and toll plants, and is effecting major savings in copper requirements.

2. In the Bell System all stimulative sales activities have been discontinued.

3. The plan of rearranging facilities to get the maximum possible use of existing cable plant is being followed even where, on a cost basis, the construction of new plant would be more economical.

4. In rural areas the use of buried copper conductors has been discontinued and steel wire supported on poles is being used.

5. Replacements solely for betterment reasons have been suspended. Replacements because of deteriorated conditions of plant are being limited to those cases where repairs, even at a cost penalty, will not properly safeguard service. The major replacement of copper wire as a result of storm damage and highway changes is being minimized, and rolled sleeve joints and patching recommended instead of replacement.

*Cable Sheath (From Both Plant Scrap and Old Reclaimed Cable), Cable Joints, Solder Sweated From Coated Wire, and Similar Scrap High in Tin and Lead, Is Melted, Sweetened With Necessary Metal to Bring to Composition, and Cast Into Solder. Photo by Mettee at Nassau Smelter, Tottenville, Staten Island*

6. Other replacements, such as dial offices for manual offices, are being confined to those cases in which it is practically impossible to give service with the old equipment.

## Salvage

The man on the street may have been impressed by the sign stenciled on cable reels "Wrap wooden lagging in bundles of 10 and return to warehouse". It is a sign that big reels are easy to salvage, but even the 2×4 protective pieces around the rim should not be destroyed. It is a sign that could be duplicated in intent at many thousands of places, wherever telephone men are working.

A commoner experience is so related by the editor of "Aluminum News-Letter":

"The fellow was in the other day to install our telephone. Now, the telephone people are always neat and clean, always leave the place just as they found it. But we noticed this fellow picking up all the little bits of copper wire he'd clipped off, some of them less than half an inch long. Next he put them in an old handkerchief . . . it was filled with just such scraps of wire. Then we realized that *all* the little wire clippings from the whole Bell System in a day would make a good size pig of copper."

In the Bell System many of the materials used in the telephone plant are not utterly expended, but may be reclaimed and re-used. Reclaiming is the specific function of the Nassau Smelting and Refining Co., a general smelter and refiner of copper, lead, zinc, tin, antimony, and their alloys from secondary sources into commercial forms such as brass, bronze, copper, babbitt, solder and related products. The plant is at Tottenville, Staten Island, near New York City; it employs 450 persons and maintains a metallurgical engineering and sales staff; it also has the responsibility for the disposition of scrap iron, paper and rubber. Purely as a metallurgical industry, the problems it solves are extraordinarily interesting

and various, for in the course of a normal year it must handle 100,000,000 lb. of junked telephone equipment. Of this waste material 75,000,000 lb. is metal, including 30,000,000 lb. of copper, 35,000,000 lb. of lead, 1,000,000 lb. of antimony, 50,000 lb. of nickel. The rest of the scrap metal is mostly iron and steel.

In 1940 about 42,000,000 lb. of recovered metal was sent back to Western Electric for re-manufacture. This included about 12,000,000 lb. of copper wire bar; more than 18,000,000 lb. of lead alloy for cable sheath alloy; some 2,000,000 lb. of lead sleeving; over 5,000,000 lb. of bronze wire bar for drop wire; some 500,000 lb. of brass billets; over 3,000,000 lb. of solder in various forms, and more than 373,000 lb. of redistilled slab zinc.

Prior to the re-smelting and refining operations are the tasks of collection, identification and segregation of the material. Mixed scrap may contain much expensive metal, but reverts to the value of the lowest grade. It is obvious, then, that this sorting should be done at the scrap source — in the shop. Perhaps an examination of Western Electric's handling of, say, nickel-bearing scrap will stimulate ideas of equal value to other manufacturers.

Western Electric manufactures a number of nickel-bearing alloys, including the permalloys, containing from 45 to 82% nickel, and "nickel-silver" containing 18% nickel, and purchases others, such as heat resisting alloys and various types of nickel steels.

Works' shops are dotted with marked receptacles, identified by color codes and stamped markings. At a centralized reclamation department, the smaller batches of scrap are assembled into commercial lots, and these collection and disposal centers are staffed by personnel who have received specialized training to sort metal intelligently.

To simplify classification and accounting for all grades of scrap, a numerical system has been adopted. All nickel alloys, for example, are in the No. 9 group, and the various grades of nickel scrap, each carefully defined, are identified by the numbers 9.01, 9.02, 9.03, etc.

Much of this scrap can be re-used quickly in casting operations. The foundry paints ends of cast ingots in accordance with a color code. This designation is lost during the hot rolling of the ingot, but is reapplied to the cooled bars. Chips from the bar milling operation are also splattered with colored paint. The color code designation is carried on through the cold rolling operations until the material is ready for delivery. Black identifying symbols are printed on permalloy scrap by a roller.

Punch press skeleton of both magnetic and non-ferrous alloys is baled for convenient charging into remelting furnaces. Nickel-silver bales are charged into an electric induction melting furnace, and bales of nickel-iron alloys are charged into an arc furnace. Some metal is inevitably carried away in the slag. To combat this, the pulverized slag is put through a magnetic separator to remove metallic particles.

Reclamation is continued to an extent in Western Electric's nickel plating operations. Short lengths of used plating anodes are placed in a rubber basket in contact with longer anodes, and thus are completely consumed. When a rack of parts being plated is lifted out of the plating tank, it is hung so that the electrolyte drips back into the tank before rinsing in a water chamber. The reclamation process seems endless. For instance, when rinse water becomes sufficiently concentrated, it is pumped back into the plating tank. Nickel nodules which form on the contact points of rotary plating drums are removed and re-used in melting operations.

Not only superfluous metal, as in punch press skeletons, but junked apparatus in various stages of assembly is grist to the reclamation mill. Nickel-bearing cores are recovered from junked coils. Contact metal is clipped from nickel-silver springs. Wherever possible, component metals are removed from dismantled parts and assemblies and distributed by classes in the scrap barrels.

In cases when identification by marking or color code is not feasible, alloys are sorted by scrutiny of the punch press skeleton. To insure positive identification, labeled samples of punch press skeleton are posted on a bulletin board near the baling press in the reclamation section.

To a nation which, in the midst of an unprecedented program of production for national effort, faces a grave shortage of metals and other vital raw materials, novel methods of conservation have become intensely fascinating. Indeed, methods which in more normal days might have been considered uneconomical have suddenly begun to seem distinctly attractive. The simple and obvious reasoning is that all production inevitably depends on the smooth and uninterrupted flow of the raw materials for manufacture, and that without these raw materials, economy itself becomes a rather fruitless practice.

# CRITICAL POINTS

By the Editor

*GRADUALLY* convinced that the Japs' assault on Pearl Harbor while their ambassador and special envoy were actually talking peace will turn out to be the dumbest act of the lunatic decade. By striking a sudden blow instead of continuing their military encroachments, step-by-step, with protestations "excuse-please" until the United States was goaded into reluctant and half-hearted action, and by blasting at Hawaii while flying a white flag in Washington instead of creating a naval "incident" of doubtful issue in the China Sea, they in one short Sunday morning united a sadly divided nation and shook its armed defenders out of the land of make-believe. Honest differences of patriotic opinion, as to whether we served our national interest best by arming ourselves or by arming Britain, instantly vanished in a common resolve to create with all speed such a swarm of ships, aircraft, artillery and soldiery as the world had never seen. Sneering remarks about "skibbies" and boastful pride in our own Navy was instantly replaced by a knowledge that here was a resourceful, bold, powerful and unscrupulous foe, to test the mettle of any force. The price of death at Pearl Harbor (more than the Confederate dead after three days at Gettysburg) is high, but the first "victory" so cheaply won spells nothing but ultimate and disastrous defeat for the victors.

**The Dumbest Act**

*TO* Washington, to a conference on steel cartridge cases, and found that (as often is the case) the news in the press association dispatches concerning this development was something less than accurate. The hopeful aim is to get something *better* than the 50-year old brass cartridge; even lacking that achievement we have the desire to get an unlimited amount of ammunition, over and beyond the million tons of brass earmarked for cartridge cases in 1942. Attention, naturally, is centered on field artillery and anti-aircraft, 37 to 105-mm. caliber ammunition, which really take the tonnage. Certain types of ammunition must be excluded for it has special requirements, such as for a non-sparking metal to avoid danger in magazines holding quantities of "semi-fixed" ammunition, and for superior corrosion resistance to withstand sea spray indefinitely . . . . . . . Germans, French and Austrians all used steel cases in action in 1918 for high explosive or gas shell, although probably not for rapid fire shrapnel barrages. Various samples studied by Ordnance officers were all composite cases — that is, the shell or body was a tube only partly closed at the base, where it was riveted or spot welded to a flat steel plate (or forced into a brass ring) that extended out to form a flange for the extracting mechanism. Usually a central hole was closed by a large brass rivet containing the percussion cap and primer. . . . . Steel cases have been made by three different American firms, each solving the manufacturing problems by unique methods. All have passed firing tests successfully and each of these firms is now rapidly preparing to go into limited production. One unsolved problem is corrosion resistance. Ammunition must be weatherproof, and should be safe to store for 15 years. What variety of plating would be sufficiently protective? Perhaps a thin copper sheath or electroplate of brass. Another question: Is the propellant powder entirely neutral to bare steel? Without waiting an answer to

**Steel Cartridge Cases for Field Artillery**

# WE ARE NOW IN THIS WAR

## We are all in it all the way

**Every single man, woman and child is a partner in the most tremendous undertaking of our American history. We must share together the bad news and the good news, the defeats and the victories—the changing fortunes of war.**

***(President Roosevelt, Address to the Nation, December 9, 1941)***

these questions, we can make millions of steel cartridge cases for gun proving and for troop training, and they can certainly be used before corrosion breaks through a commercial protective finish. . . . . Frankford Arsenal has been working on the problem for the last four years, and this work has been supplemented during 1941 by about a dozen important manufacturers. Any responsible American firm which has idle press shop and heat treatment facilities can get adequate direction and help to avoid processes that are already shown to be unsatisfactory by consulting the Chief of Ordnance, U. S. Army, in Washington. . . . . One can avoid welding experiments, for instance. A large number of trials indicate that this mass production process is inadequate. How nice it would be if a short piece of thin seamless tube could be flash welded to a forged base plate! Unfortunately the softened region at and along the weld either is not strong enough to resist the explosion of the propellant powder, or is not elastic enough to spring back from the gun chamber for easy rejection.

*GRIEVING* moderately over those few desirable things that used to come from Germany. (Strange it is that a people which makes such excellent beer, such appealing toys, such noble music — all elements of good fellowship — can act so savagely toward their neighbors!) Among these minor victims of the blockade is the *tonerde* or alumina sold for a metallographic polishing medium under such names as "diamantine" and "sapphirine". Of course American metallographers are now doing much electrolytic polishing, requiring no abrasive, but a really fine polishing medium is still necessary when studying cast iron or non-metallic inclusions. D. L. Edlund, research metallurgist of Vanadium Corp. of America, writes that he has had great success with chromium oxide either alone or mixed with magnesium oxide. Then, too, metallographers can buy the finest alumina of American manufacture and levigate it for themselves.

**American Polishing Media for Americans**

*OVER TO* Ansonia, from New Haven, where 93 years ago Almon Farrel and his son Franklin opened a shop for making machinery for the growing brass industry of the region. On this steep Connecticut hillside, about the worst possible site for a big factory, has stub-

bornly grown one of the nation's notable plants for making extra heavy machinery, now the home plant of Farrel-Birmingham Co. In a huge foundry, G. L. RICHTER, the assistant metallurgist, explained the Rand-Upson molding method (doubtless responsible for a notably dust*less* atmosphere). As probably everyone knows, this uses a finely ground, quick setting cement as a binder for clean, fine silica sand, instead of a natural molding sand, or a sand artificially bonded with clay and organic materials. At the Ansonia foundry all sand and cement handling is done in tightly enclosed rooms or conveyors and stored in hooded bins; even the transfer weigh-car and pug mills are in a glass-cased passageway exhausted through a dust catcher. . . . Steel molds are made of all new sand with about 10% cement; iron molds (and much backing of massive steel molds) are made of old sand plus about 7.5% cement. Measured amounts of water are added, and the mixture controlled by the standard American Foundrymen's Association sand tests for moisture, permeability and compressive strength. . . . Such a sand-cement mixture needs very little tamping (in fact, tramping with the feet is enough) but must be molded within two hours. Sometimes retarders are added, else the cement set too quickly. All the molding appears to be core molding, for the molds, well reinforced with twisted rods, especially at corners, are stripped from the boxes and set on stiff *flat* base plates where they cure for 24 hr. . . . . Molds are then assembled, weighted down, and sometimes held together with tierods, but even very large items can be poured without flasks. The molds crack after the metal has well solidified, and so the castings shake out cleanly, and the used sand is easily pulverized. Even its interior appears damp, and a large permeability (say 200, as compared to 80 for a natural sand) avoids any "gassing" of castings by the steam which forms. Resultant castings are very smooth, "file finish" is the shop description. . . . Molds for excessively large or long castings, like a 40-ft. grinder bed, are built up as an assemblage of accurate cores in a pit, founded on a strong bed of cement-bonded sand. The sides of the pit are backfilled and lightly tamped to strengthen against spread during the pour. Extreme accuracy of individual mold sections (cores) and constancy of volume during curing, is absolutely necessary in any such work as this.

### Cement as a Binder for Foundry Sand

ADDENDUM ON ROLLS: RICHTER is justly proud of his associates' ability to make enormous rolls for steel mills, brass mills, paper mills, rubber mills, sugar-cane mills. (Funny that the word "mill" has grown from a meaning of "grinding equipment" to a meaning of "flattening equipment"!) Faithful readers of *Critical Points* have already a slight acquaintance with the unique founding methods, through their vicarious visit to the Canton, Ohio, plant of United Engineering and Foundry Co. with KARL SCHMIDT, its metallurgist, in March of 1941. Hard surfaces must be chill cast, for these cylinders are too tremendous to be quenched with any speed. But how get off the surplus metal down to a smooth finish? Amazed, at Ansonia, to find such a chilled iron roll, scleroscope 75 hard, being *machined* with a tool 12 in. broad. This was merely a plate of carbon toolsteel, ⅜ in. thick, water hardened from 1450° F. Speed was literally snail's pace; the tool holder was stationary; the chips came off like bundles of finest broom-straw.

### Machining Chilled Iron With Carbon Toolsteel

*AT THE* Bridgeport plant of Manning, Maxwell & Moore, Ashcroft Valve and Gage Division, and surprised by the number of special metals worked into the product. Pressure gages ranging from vacuum to 50,000 psi., and safety and oil relief valves ranging from 5 to 2800 psi. rated capacities and used at temperatures from −250 to +1250° F. require various metals from common brass and iron to high tungsten steel with high resistance to creep. . . . . Ashcroft, the founder, just 90 years ago acquired American rights to manufacture Professor Bourdon's new device, wherein a tube bent into a circular arc straightened out slightly when internal pressure was increased and this movement was geared to a pointer. Bourdon tubes, when filled with gas, have ever since been commonly used for measuring pressures and, when filled with mercury, for measuring temperatures through its change in volume (and imposed pressure). In the thermometers finest capillary tubing connects the mercury bulb at the hot end to the gage at a convenient location; this tiny tube must have a perfect inside surface else mercury squeezes into any defect when the temperature (that is, the pressure in this closed system) goes up, and then

### Accurate Measurements of Extreme Pressures & Temperatures

oozes slowly back out when pressure drops. Such defects are avoided in the tube mill by careful selection of stock and a long program of draws, each of small draft. . . . ALBERT EPLETT, chief metallurgist, described the training of welders competent to join capillaries to bourdon tubes flattened into a ribbon about ¾ in. wide, but with walls only 0.007 in. thick. Selected workmen are instructed in the laboratory; defects in welds and aberrations in technique are marked as they occur and the work then cut apart and examined microscopically. Gradually the welder acquires confidence; pride of workmanship is however a prime requisite. Each welder tests every weld he makes in production, first by bubbling air through the tube to make sure that the opening is clear, and then with cylinder gas at 1000 psi. to prove its soundness. . . . . Bourdon tubes are made of brass, phosphor bronze, special nickel-molybdenum steel, 5% chromium - molybdenum steel, austenitic stainless (columbium stabilized), or beryllium copper, depending on the services required. Thin walled tubing for low pressures is cold drawn, while tubes with heavy walls are rifle drilled and reamed from solid bars, turned and ground outside for *uniform* wall thickness. Thin walled tubes, drawn to shape, are filled with powdered mica and bent to correct curvature. Heavy walled tube-ends are threaded, the tube filled with fine mica, heated and bent to correct radius. Such tubes are stress relieved after each operation to be sure that the metal finally is uniformly stressed, internally, so its reactions to internal pressure will be constant and reproducible. After hardening and tempering, if the alloy is hardenable, the end connections are welded on or brazed. . . . Beautiful were the shining thermometers for dairies, made completely of stainless steel — bulb, capillary, protective braid, gear mechanism — the case itself a brilliant white.



**Segregate That Scrap**

*COMPLETED* a survey of secondary copper (scrap) for the Advisory Committee to O.P.M. on Metals Conservation and Substitution, and more than ever impressed with the necessity of *segregating* plant scrap cleanly into classes. Unlike aluminum, contaminated copper *can* be resmelted and refined to get pure metal. However this is costly, time consuming, and locks up metal in process, so the principal aim of remelter of both aluminum and copper secondaries is to mix the available scrap in such proportions that the product can be brought to marketable composition without adding any higher grade, unalloyed metal for "sweetening". As far as copper is concerned, not so many months ago there was a large civilian demand from brass foundries making plumbing goods, and these analyses had a rather large tolerance for adventitious elements ("impurities"), so the problem of economical disposal of de-graded metal was an easy one. Now the situation is quite different, and the army, navy and air corps require very large tonnages of bronzes with sharply limited amounts of lead, zinc and iron — those omnipresent elements in circulating scrap metal. In one plant making bearings the following was observed: Most of the production was an aircraft bronze so low in lead that virgin copper and tin were required; two-thirds of the rough casting was machined away, and this large amount of scrap was so contaminated by turnings from a few leaded bronze bearings also being made that none of it could be reclaimed as the original alloy. The result was the consumption of 4½ lb. of virgin metal for every pound shipped as finished bearing! . . . . An extreme case, perhaps, but indicative of the fact that plant scrap *must* be carefully segregated to avoid debasement. Clean scrap — even aluminum — can be reclaimed into its original form.

# REVEALING THE MICROSTRUCTURE OF 24S ALLOY

By F. Keller
and R. A. Bossert
Metallurgical Division
Aluminum Research Laboratories
New Kensington, Pa.

*General use* of Alcoa 24S alloy in aircraft construction has stimulated interest in the microstructural characteristics of wrought products of this alloy — especially in the microstructural changes resulting from various heat treatments. It is the purpose of this paper, therefore, to describe metallographic methods for the examination of this alloy and to illustrate the results obtained. Examination of suitable polished and etched specimens reveals many facts about the condition of 24S alloy products.

*Effects of Alloying* — Other elements added to aluminum may be present in the resulting alloy in several different forms. They may be retained in solid solution, be present as particles of the elements themselves, or they may be combined with aluminum as intermetallic compounds. These solid solutions, particles of the elements and intermetallic compounds make up important details of the structure revealed by the microscope.

Alcoa 24S alloy contains nominally 4.4% copper, 1.5% magnesium, 0.6% manganese, and small percentages of silicon and iron. Copper and magnesium are appreciably soluble in solid aluminum; the other elements are soluble only to a limited extent; thus, the former elements constitute the principal hardening constituents. Moreover, the solubilities of copper and magnesium change appreciably with temperature. They are much more soluble at elevated temperatures than at room temperature. This variation in solubility over a wide range of temperature allows the alloy to be hardened and strengthened by suitable heat treatments.

In the cast form, 24S alloy exhibits a polyhedral grain structure with cored solid solution zones and a discontinuous network of the microconstituents along the grain boundaries and at the interstices of the dendrites. Such a structure is shown in Fig. 1. Microstructure of *wrought* products made from a cast ingot is, in general, influenced by the chemical composition, the rate of solidification, the type and amount of working and by the various thermal treatments that the material receives. During fabrication, the alloying elements become more uniformly distributed throughout the matrix and the pattern of the constituent network is altered.

*Preparation of Specimens* is not difficult when proper technique is employed. Methods for polishing aluminum alloys for microscopic examination are similar to those employed for other materials, except that especial care must be taken to avoid surface flow and deep scratches. There are different procedures by which satisfactory preparation of specimens can be obtained. Practices described in this paper were used originally by E. H. Dix, Jr., now chief metallurgist of Aluminum Research Lab-

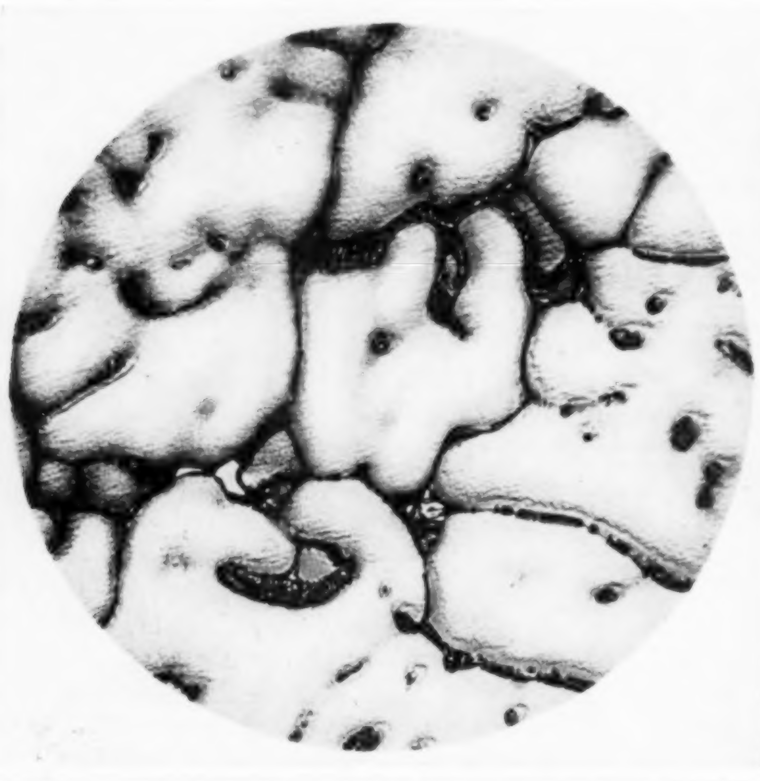


*Fig. 1 — Mag. 500×. Etch: HF-HCl-$HNO_3$ solution for 15 sec. Microstructure characteristic of a cast aluminum alloy of 24S composition. The matrix contains some of the alloying elements in solid solution. The eutectic network at the grain boundaries and interstices of the dendrites is comprised of the constituents Al-Cu-Mg, $CuAl_2$, $Mg_2Si$, and Al-Cu-Fe-Mn. Bordering this network are zones of solid solution coring.*

oratories, and described by him in *Chemical & Metallurgical Engineering* in 1922. They have been used at these laboratories for more than 17 years and they have been found satisfactory for all of the many varieties of aluminum alloys. The various steps in the preparation of an aluminum alloy sample for microscopic examination are carried out in the following order:

A. Obtain plane surface by rubbing specimen on a medium mill file.

B. Remove marks left by file by rubbing specimen by hand on 0, 00, and 000 metallographic emery papers in the order named. These papers should be lubricated with kerosene or a mixture of kerosene and paraffin to prevent smudging.

C. Polish on a rotating disk covered with a "kitten's ear broadcloth" pad. The disk should be operated at about 300 rpm. and No. 600 alundum flour should be used for the abrasive.

D. Polish finally on a rotating disk covered with a kitten's ear broadcloth pad. The disk should be operated at about 150 rpm. with heavy magnesium oxide powder on the pad. For moistening the pad, *distilled water,* not tap water, should be used.

After the polishing operations are completed, the specimen should be washed by holding it under a stream of warm water and dried by blowing the water from the surface. The polished surface should not be touched with the fingers or rubbed during the washing or drying operations; otherwise the finish may be ruined.

*Etching Practices* — The above operations, as well as the etching practices, were described by F. Keller and G. W. Wilcox in Metal Progress, April 1933, with several pages of plates illustrating the microstructural characteristics of samples prepared in the manner as outlined, after the use of various etching solutions. For the duralumin-type alloys, two etching solutions are recommended, one for alloys in the cold worked and annealed conditions; the other for alloys in the heat treated condition. The etching characteristics of the microconstituents of 24S alloy obtained with these two etching solutions are shown in Fig. 2, which is published as a data sheet, on the page opposite.

*Etching Cold Worked and Annealed* 24S Metal — Microstructures of cold worked 24S or of annealed 24S sheet (24S-O) can be developed satisfactorily by the use of an etching solution recently developed by R. A. Bossert at Aluminum Research Laboratories:

| | |
|---|---|
| Sodium hydroxide (NaOH) | 1 g. |
| Sodium carbonate ($Na_2CO_3$) | 1 g. |
| Solution containing 0.5% each of $ZnCl_2$ and $SnCl_2$ | 4 cc. |
| Water | 94 cc. |

This etching solution should be made up as it is needed; it should not be kept as a stock solution. Prepare the solution containing the zinc chloride and stannous chloride by adding 0.5 g. of each to 99 cc. of water; several pieces of clean tin should be kept in it to prevent oxidation.

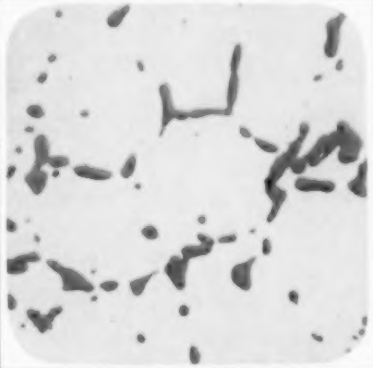
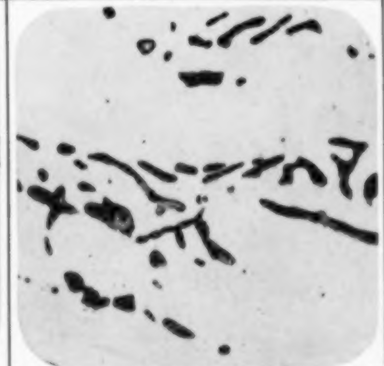
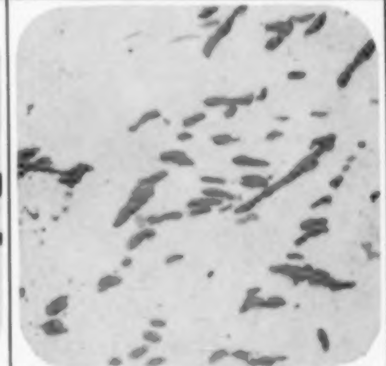
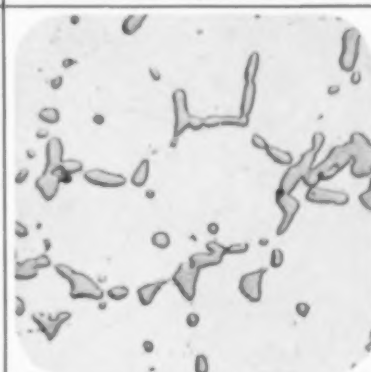
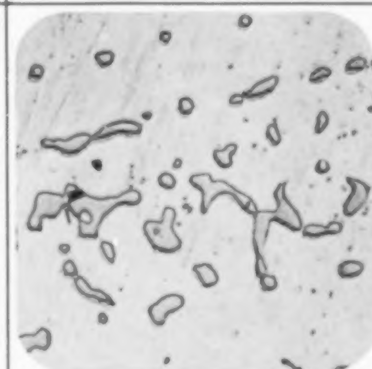
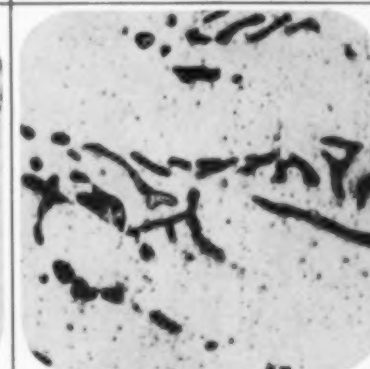
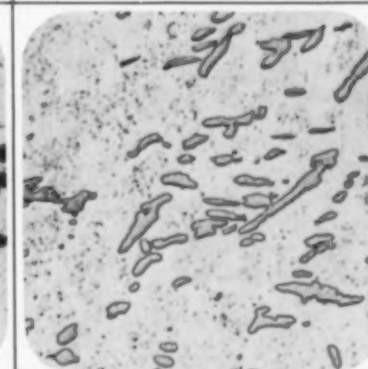
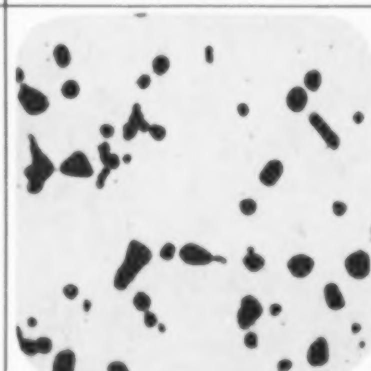
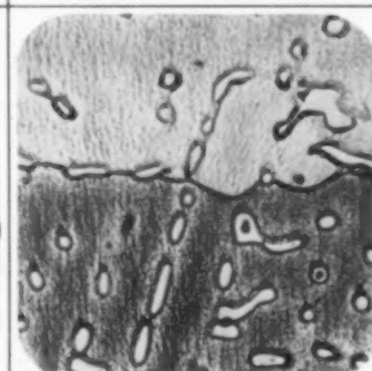
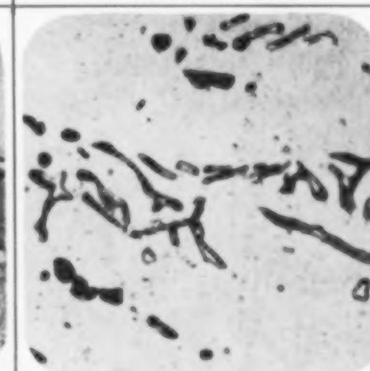
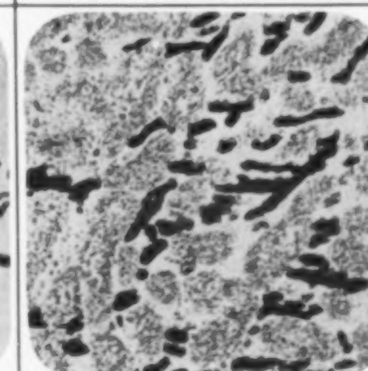
Etching is accomplished by immersing the specimen in this solution at room temperature until the etched surface becomes coated with a heavy black deposit. This requires from 3 to 5 min. The deposit is then removed by immersion in concentrated nitric acid, after which the specimen is washed in water and blown dry.

With this etching solution, the microstructures of the alloy in the hard rolled and annealed conditions can be revealed without undue attack on the matrix or the microcon-

4.4 % Cu
1.5 % Mg
0.6 % Mn
Bal. Al
Incidental Si and Fe

# CONSTITUENTS OF 24S ALLOY
## ETCHING CHARACTERISTICS

By F. Keller
and R. A. Bossert
Aluminum Research Laboratories

| ETCHING TREATMENT | CONSTITUENT, (As It Appears in Synthetic Alloy of Extreme Purity) | | | |
|---|---|---|---|---|
| | Al-Cu-Mg | $CuAl_2$ | $Mg_2Si$ | Al-Cu-Fe-Mn |
| No etch; Photographed as polished |  |  |  |  |
| $NaOH-Na_2CO_3-(Zn.Sn)Cl_2$ solution for 5 min. Cleaned with conc. $HNO_3$ |  |  |  |  |
| $HF-HCl-HNO_3$ solution for 15 sec. |  |  |  |  |

stituents. The results obtained on sheet samples are illustrated by Fig. 3 and 4. In these conditions of 24S alloy, the principal hardening constituents (Al-Cu-Mg and $CuAl_2$) are largely out of solution. As a result, very little contrast in color is developed between the grains of different orientation. (This etching procedure is recommended where it is desired to examine the grain structure of 24S-O sheet samples). The effect of the etching solution upon the various microconstituents encountered in the 24S type of alloy is shown in the data sheet. Since the $NaOH$-$Na_2CO_3$-$(Zn.Sn)Cl_2$ etching solution does not appreciably color or attack these constituents, it cannot be employed for their identification.

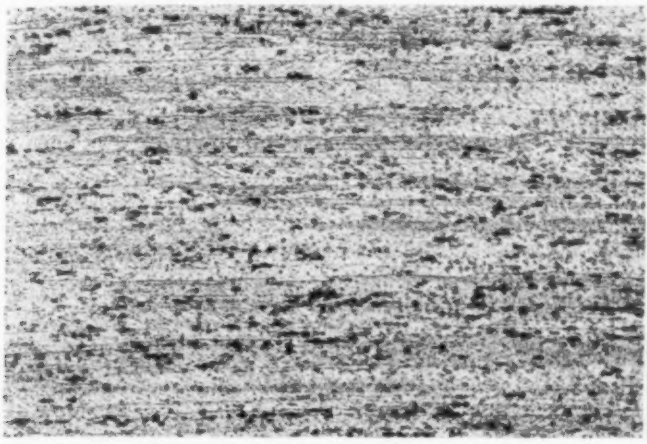
*Etching 24S-T Products* — The etching solution used for revealing the structure of the heat treated temper of 24S alloy (24S-T) was described by Mr. Dix and the senior author in *Mining & Metallurgy,* 1928, p. 327, and is made up as follows:

| | |
|---|---|
| Hydrofluoric acid (conc.) | 1 cc. |
| Hydrochloric acid (conc.) | 1.5 cc. |
| Nitric acid (conc.) | 2.5 cc. |
| Water | 95 cc. |

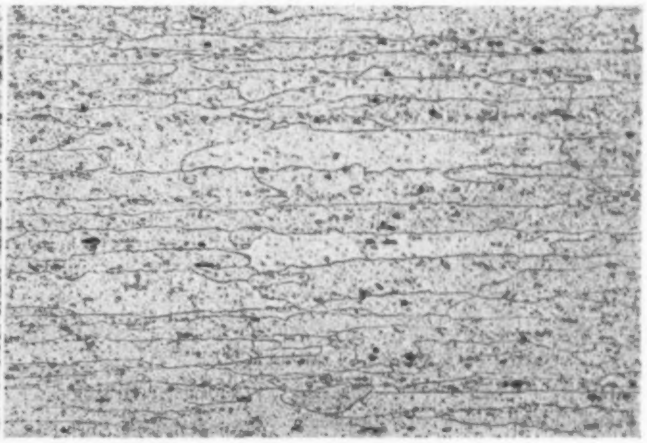
Etching is accomplished by immersing the specimen, ***polished surface up,*** for 10 to 20 sec. Then the specimen is washed free of the etching solution in a stream of warm water and blown dry. Caution should be exercised that the etched surface is not touched; otherwise, some of the etching products may be removed and the appearance would be unsatisfactory. This reagent develops the structures of 24S-T sheet, cast 24S alloy ingots, and of both "as cast" and heat treated aluminum-copper alloy castings, by revealing the grain boundaries, grain orientation, and by outlining or coloring the various microconstituents.

When etched with the HF-HCl-$HNO_3$ solution, 24S-T alloy tends to develop many small etching pits. These are sometimes confused with precipitated particles of constituent. Close examination, however, will show that the outline of the pits in the light colored grains have a triangular shape; whereas, those in the dark grains have a square shape. This observation will aid in determining whether particular areas contain etching pits or particles of precipitate.

*Double Etch* — In some instances, the precipitated particles may be the same color as the matrix or they may be too small to be resolved satisfactorily. The contrast between the precipitated particles and the matrix can be improved by using a double etching treatment. This consists in etching the polished specimen for about 1 min. in 25% nitric acid at 70° C. followed by quenching in cold water. The treatment tends to outline and color the very small particles. Then the specimen should be etched in the HF-HCl-$HNO_3$ solution previously recommended to develop the grain boundaries



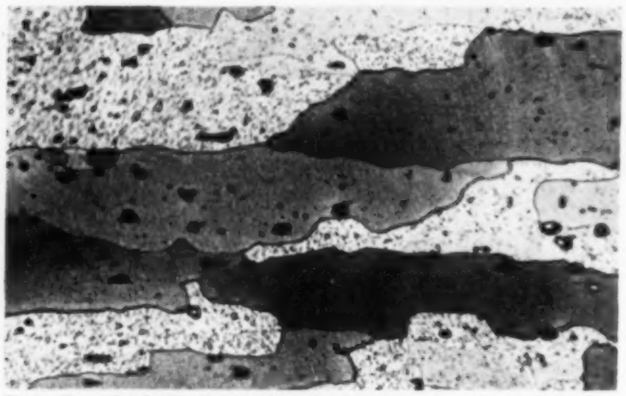
The alloying constituents are largely out of solution in this temper. The grains are distorted and fragmented from plastic deformation; consequently, the grain boundaries cannot be revealed clearly



Annealing has relieved the effects of plastic deformation and fragmentation by causing recrystallization. The alloying constituents are not dissolved by this treatment; consequently, the amount and arrangement are about the same as in the hard rolled material

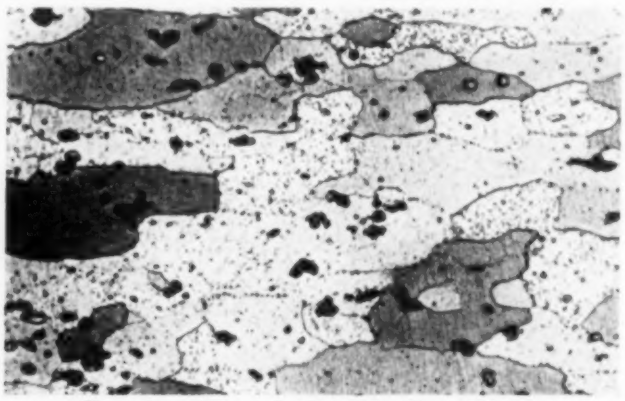
***Fig. 3 and 4 — Hard Rolled 24S Sheet (at Left) and Annealed 24S-O Sheet at 100×, Etched With $NaOH$-$Na_2CO_3$-$(Zn\cdot Sn)Cl_2$ Solution***

*Effect of Speed of Quenching on 24S Cold Rolled Sheet, After Solution Treatment at 920° F. All at 500×, etched 15 sec. in HF-HCl-$HNO_3$*



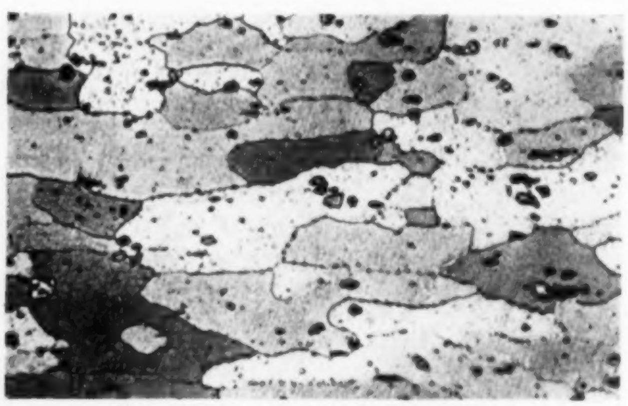
The principal alloying constituents have been largely dissolved by the heat treatment and have been retained in solid solution by quenching. In this temper, undissolved particles of Al-Cu-Mg and $CuAl_2$ and particles of the insoluble $Mg_2Si$ and Al-Cu-Fe-Mn constituents are seen in the solid solution matrix

*Fig. 5 — 24S-T, Rapidly Quenched in Cold Water*



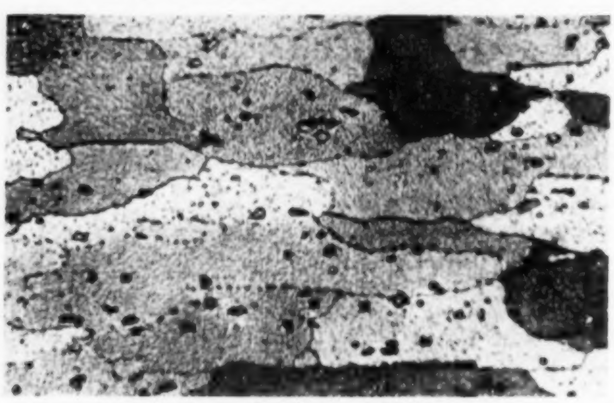
As a result of the slower rate of quenching, note some precipitation at the grain boundaries (small dark particles)

*Fig. 6 — Quenched in Boiling Water*



This type of quenching has resulted in decreased grain contrast and in the formation of larger particles of a precipitate at the grain boundaries

*Fig. 7 — Quenched in Air Blast*



This type of cooling results in greatly decreased grain contrast and in much precipitation along grain boundaries and within grains

*Fig. 8 — Cooled in Still Air*

and grain contrast. The double etching treatment is also useful for revealing the fine precipitate that occurs when duralumin type alloys are subjected to an artificial aging treatment. Examples of the technique are Fig. 13 (25% $HNO_3$) and Fig. 14 (double etch).

*Microstructure of 24S Alloy* — As already noted, the microconstituents of 24S alloy are Al-Cu-Mg, $CuAl_2$, $Mg_2Si$, and Al-Cu-Fe-Mn. The micrographer should remember that only the first two have appreciable solubilities; the others are essentially insoluble in this alloy and their size, shape and general distribution remain unaltered by various heat treatments.

In the hard rolled condition of 24S alloy, the alloying constituents are largely out of solution but as shown in Fig. 3 the grains are distorted and work-hardened and exhibit an unrecrystallized structure comprised of grain fragments. When hard rolled material is annealed, the strain hardening resulting from plastic deformation is relieved and recrystallization occurs. Since annealing is accomplished in a temperature range where there is little tendency for any change in solid solubility, the size and distribution of the hardening constituents are essentially the same in the annealed condition as in the hard rolled condition. (Compare Fig. 3 with Fig. 4.)

When an alloy of this type is heat treated at 920° F., however, the principal alloying constituents Al-Cu-Mg and $CuAl_2$ are dissolved in the solid solution matrix. By quenching the material rapidly from this heat treating temperature, it is possible to retain the soluble alloying elements in solid solution. During subsequent aging at

room temperature for several days after heat treatment, small amounts of these alloying elements precipitate, but as sub-microscopic particles, which action hardens and strengthens the solid solution matrix.

***Effect of Improper Heating Conditions on 24S Cold Rolled Sheet Properly Quenched in Cold Water. 500×, etched 15 sec. in HF-HCl-$HNO_3$***

Solution of constituents is largely incomplete and the grain contrast is low because of the short heat treating period. Compare with Fig. 5 of properly heat treated material

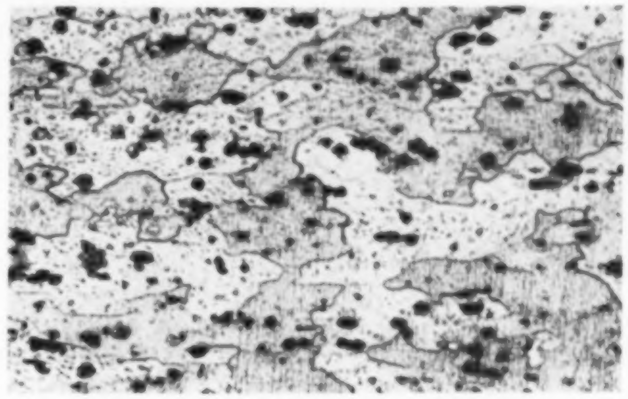


*Fig. 9 — Insufficient Time (1 Min.) at Correct Temperature (920° F.)*

The heat treating temperature, in this instance, was not high enough to cause solution of the required amount of the constituents Al-Cu-Mg and $CuAl_2$. As a result, many particles of these constituents exist and the grain contrast is low

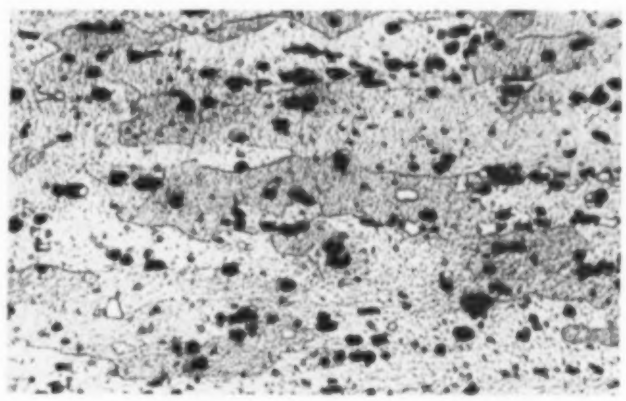


*Fig. 10 — Sufficient Time (15 Min.) But at Low Temperature (850° F.)*

This treatment has caused melting of eutectic areas and of the solid solution along grain boundaries. Thus, the microstructure shows partial reversion of the metal to a cast condition

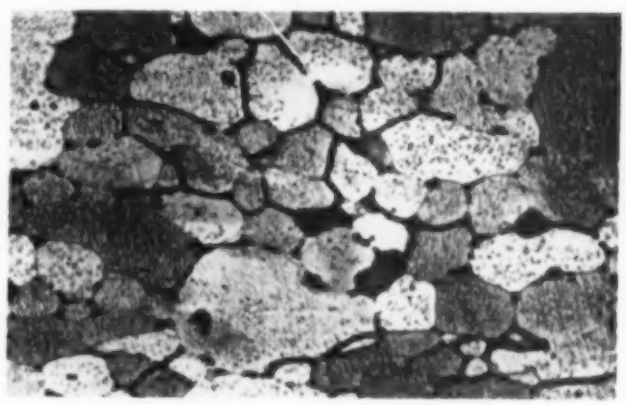


*Fig. 11 — Overheated to 980° F.*

Thus, the microstructure of the heat treated temper of 24S alloy (24S-T) consists of a solid solution matrix in which are embedded some undissolved particles of Al-Cu-Mg and $CuAl_2$, as well as particles of insoluble $Mg_2Si$ and Al-Cu-Fe-Mn constituents. Those portions of the constituents that were dissolved during heat treatment are retained in solid solution by the quenching (or they exist as sub-microscopic particles of a precipitate phase). The characteristic microstructure of heat treated and rapidly quenched 24S sheet (24S-T) is illustrated by Fig. 5.

*Effect of Quenching Rate* — When 24S alloy products are not quenched rapidly from the heat treating temperature, there will be a tendency for preferential precipitation to occur along the grain boundaries. Evidence of this precipitation can be detected in the microstructure; consequently, microscopic examination can be usefully employed to check the results of a commercial heat treatment.

The microstructure of a sample which was quenched in boiling water instead of in cold water is shown by Fig. 6. Because of the slower rate of quenching obtained in boiling water, some precipitation has occurred at the grain boundaries. As the rate of quenching is further decreased, the precipitate particles tend to become larger and more numerous. Furthermore, less contrast in color can be observed between the grains of different orientation. The changes in microstructure that result when 24S-T sheet is quenched by an air blast or is allowed to cool in still air are illustrated by Fig. 7 and 8.

*Effect of Heat Treating Time* — Insufficient time at the heat treating temperature will produce only partial solution of the alloying constituents; thus, material that is not held long enough at the heat treating temperature will

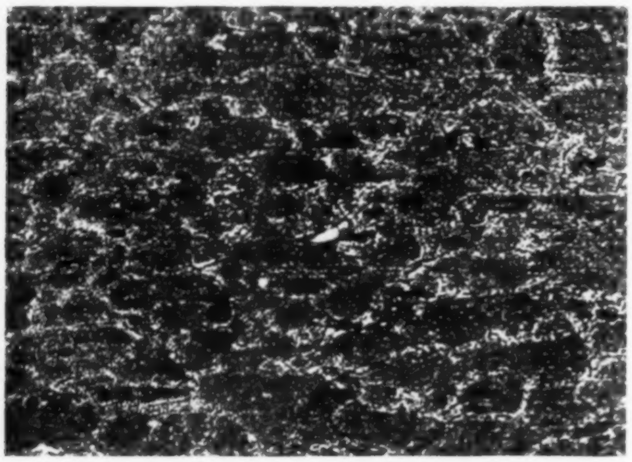


*Fig. 12 — Microstructure of 24S Sheet That Originally Was in the Heat Treated Temper and Which Subsequently Was Annealed by Heating for 2 Hr. at 650° F. This treatment results only in partial softening because of the size and distribution of the precipitate particles. Compare this structure with that of fully annealed material (Fig. 4)*

show evidence of many undissolved particles of Al-Cu-Mg and $CuAl_2$. This is illustrated by Fig. 9 which represents 24S-T sheet that was held for only 1 min. at 920° F. before quenching. As a matter of fact, *complete* solution of all Al-Cu-Mg and $CuAl_2$ particles is seldom obtained in the commercial heat treatment of 24S products; consequently, some particles of these constituents are usually found in the microstructure. Thus, an insufficient heat treating period can be inferred only when more than the normal amounts of these constituents remain out of solution. Compare Fig. 9 with Fig. 5.

*Effect of Heat Treating Temperature* — A heat treating temperature of 910 to 930° F. is required to produce substantial solution of the hardening constituents of 24S alloy. Heat treating temperatures below this range will cause only partial solution of the constituents; therefore the microstructure of material heat treated somewhat below 910° F. will be of the same character as that obtained when insufficient time at the proper temperature is used. The principal difference will be in the amount of grain contrast that is developed. Material heat treated for 1 min. at 920° F. will show more grain contrast than material heat treated for 15 min. or more at 850° F. The microstructural characteristics of the material, after it has been heat treated for 15 min. at 850° F. and quenched, are shown by Fig. 10.

*Overheating* — While the proper range for heat treatment is from 910 to 930° F., if the temperature at any time reaches or exceeds 936° F. incipient melting occurs, with the result that a partial reversion to an "as cast" structure is obtained. Microscopic examination provides a very good method for detecting small amounts of melting, the result of transgressing the rather narrow range between proper solution treatment and overheating. When overheating occurs in 24S alloy, small areas of eutectic composition melt and some fusion occurs at the junctions of groups of grains. The microstructural features which are indicative of incipient melting resulting from overheating are

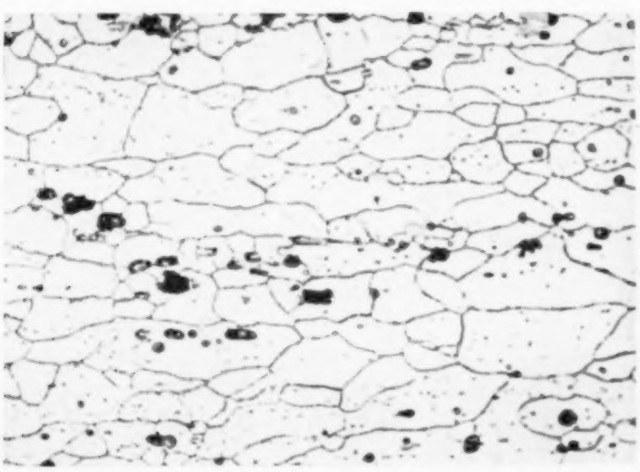


*Fig. 13 — Etched With 25% $HNO_3$ at 70° C.*

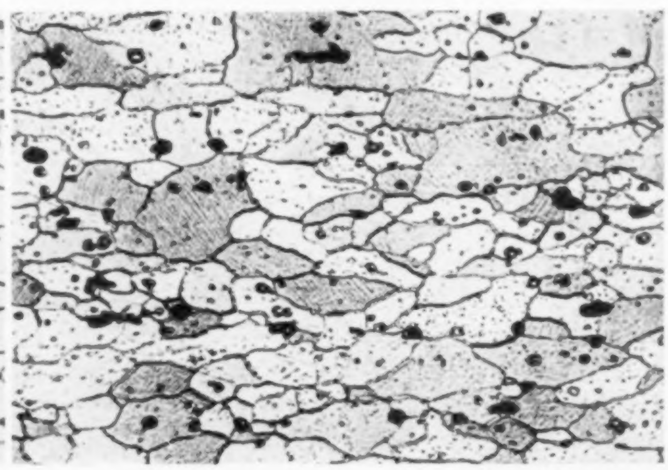


*Fig. 14 — Fig. 13 After Etching 15 Sec. in HF-HCl-$HNO_3$*

***Grain Boundary Precipitation in 24S-T After 1 Hr. at 400° F. Magnification 500×***

illustrated by Fig. 11. This sample was heat treated at 980° F.

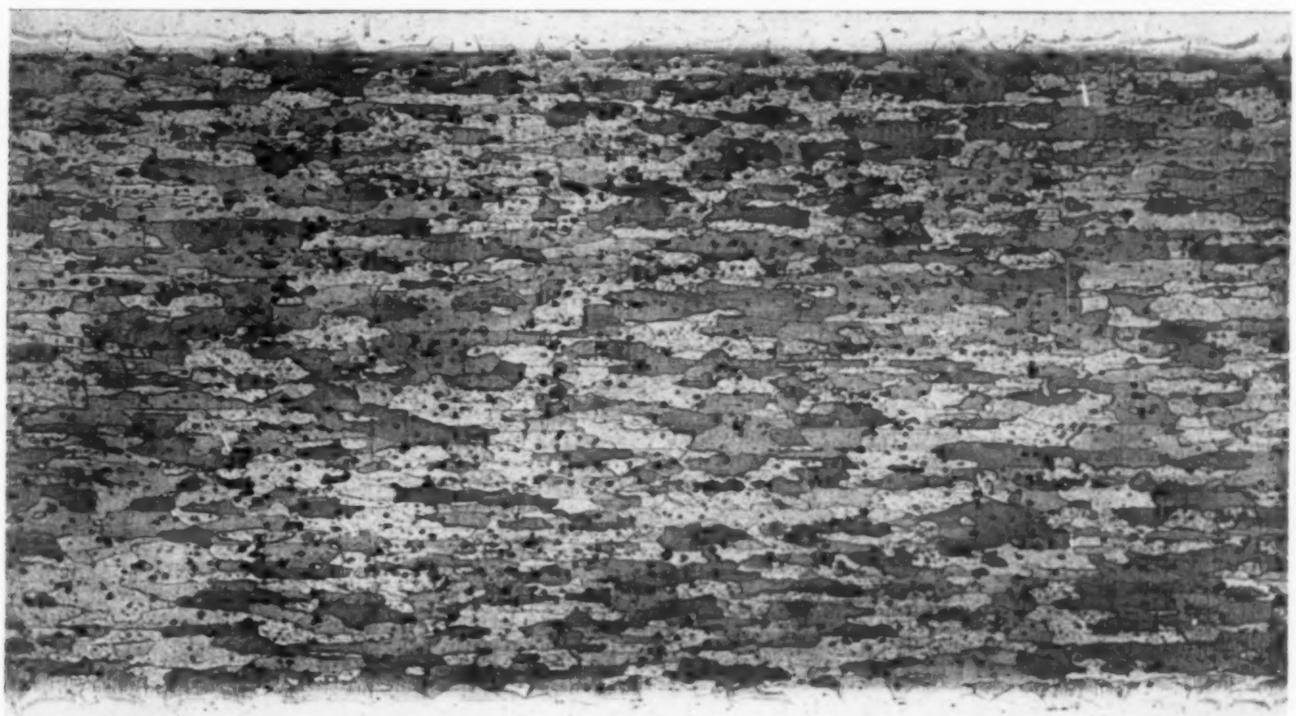
*Annealing of 24S-T* — Ordinarily, the 24S-O temper is produced by the annealing of cold worked 24S sheet. At times, however, it may be desirable to anneal heat treated 24S sheet (24S-T). Under such circumstances, an annealing cycle consisting of a high temperature heating followed by a slow cool must be used to obtain complete softening. This practice consists in heating the material at a temperature from 750 to 800° F. for 2 hr. and cooling in a furnace at not over 50° per hr. to at least 500° F.

This practice is necessary in order to precipitate and coalesce the hardening constituents to such a size that they will have little or no hardening effect on the matrix. If the ordinary annealing temperature of 650° F. is employed for softening heat treated material, only partial softening will occur. The microstructural characteristics of 24S-T sheet which was annealed by heating at 650° F. for 2 hr. are illustrated at 500 diameters magnification by Fig. 12, after etching 15 sec. in the HF-HCl-$HNO_3$ solution.

*Reheating* — Attempts have been made occasionally to obtain improved forming characteristics for 24S-T sheet by conducting the forming operations while the material is at some temperature around 400° F. The effects of a reheating of this character can be detected readily in the microstructure. For instance, a 24S-T sheet sample that had been reheated 1 hr. at 400° F. is illustrated by Fig. 13 and 14. In Fig. 13, precipitation along grain boundaries resulting from reheating has been revealed by etching the sample in 25% $HNO_3$ at 70° F. This is the first part of the double etching treatment previously described. Figure 14 shows the structure of the same sample after it had received the second part of the double etching treatment. In the latter illustration, the heavy grain boundary precipitate and the decreased grain contrast resulting from reheating are evident.

*Alclad 24S Sheet* — One of the 24S alloy products that has been used to a large extent in aircraft construction is Alclad 24S-T sheet. As is well known, this has a core of 24S alloy combined with surface layers of high purity aluminum. With this combination, the high strength of the 24S-T core is obtained, together

*Fig. 15 — Full Cross Section of 0.040-In. Alclad 24S-T Sheet. Etching differentiates between surface layers of high purity aluminum and 24S-T core. Diffusion zones, resulting from migration of copper and magnesium into the coating layers, are evident. Particles scattered through the core are chiefly $Mg_2Si$. 100×. Etched in HF-HCl-$HNO_3$ solution 15 sec.*



with excellent resistance to corrosion afforded by the coating layers. Its resistance to corrosion is developed not only by the covering action of the pure aluminum surface, but also by electrolytic protection of the core by the coating.*

Microstructural features of Alclad 24S-O and of Alclad 24S-T can be revealed very satisfactorily by the two etching solutions previously described. The first solution is used for developing the microstructure of the core of the soft Alclad 24S-O; the latter is used for the structure of heat treated Alclad 24S-T. Microscopic examination of cross sections provides a very effective means of checking thickness and continuity of the high purity coating layer, the character of the heat treatment, and the extent of diffusion of the soluble elements from the core into the coating layers during heat treatment. The two etching solutions will reveal the structure of the core material of Alclad products but not that of the coating; thus it is possible to distinguish between the coating and the core portions of this product. Microstructure of a complete cross section of Alclad 24S-T sheet is illustrated by Fig. 15.

*Magnifications for Examining 24S Alloy Products* — The metallographic examination of 24S alloy products is ordinarily made at magnifications of 100 and 500 diameters. Generally, a magnification of 100 diameters is used for determining grain size, grain contrast, detection of segregation and distribution of constituents. The higher magnification is employed in the detection of precipitation resulting from slow quenching or reheating, for evidence of overheating, and for the identification of the various microconstituents. For some of the structures obtained in 24S alloy products, a magnification of 250 diameters can be used to advantage in revealing much that can be observed at both 100 and 500 diameters.

*Conclusion* — It is believed that the polishing and etching procedures described herein will be of interest to those engaged in the inspection of the 24S alloy products used in the aircraft industry. When these methods are followed closely and the proper skill is attained, it is possible to determine many pertinent facts about 24S alloy products from metallographic examinations.

*E. H. Dix, Jr., "'Alclad', A New Corrosion Resistant Aluminum Product"; Technical Note No. 259, National Advisory Committee for Aeronautics (August, 1927).

F. C. Pyne, "Ten Years' Experience with Alclad Materials in Aircraft". *S.A.E. Journal*, 1939, p. 221.

# ROLLING A MAGNESIUM ALLOY*

By W. R. D. Jones and L. Powell

*TEN-GAGE* sheets were produced by rolling cast slabs of the magnesium alloy described below, and slabs extruded from a chill-cast circular ingot teemed from the same ladle of molten alloy. The commercial material chosen was "Elektron AM503" (nominally 1.5 to 2.0% manganese, 0.3% silicon, balance magnesium) which is recognized as a generally serviceable alloy. These sheets were then reduced to 16-gage by a combination of hot and cold rolling, so that the finished sheets had received 0, 5, 10, 25, 50, 75, and 100% cold extension. The sheets were annealed at 0°, 100°, 200°, 300°, 400° and 500° C. Tensile test pieces were prepared transverse, longitudinal, and at 45° to the direction of rolling. All this experimental work was done along the lines described in a contribution to the *Journal* of the British Institute of Metals in 1940 (page 331).

The mechanical properties in the direction at right angles to that of rolling were higher than those in other directions, and the differences between longitudinal and transverse test pieces were greater the greater the cold work. Cold rolling and annealing did not improve the properties of hot rolled sheets.

The following remarks apply to sheets produced from the cast slabs:

While small amounts of cold rolling increased slightly the *tensile strength*, there was a more than corresponding decrease of ductility. Heavier cold work up to 75% extension does not further affect the strength appreciably. Thickness of the sheet before rolling was an important factor.

Mechanical properties of cold rolled sheets of this magnesium alloy are not improved to any important extent by annealing. If annealing is carried out the temperature should not be higher than 575° F. Rolling produces marked directional properties which are not eradicated by annealing at temperatures even up to 900° F.

Cold work above 50% extension seriously decreased the values for ultimate stress, particularly in the "weak" directions. There is some evidence that even very small amounts of cold work are harmful, especially if *(Continued on p. 142)*

*Abstracted from *Journal*, Institute of Metals, Vol. 67, 1941, p. 153.

# A.S.M.E. TALKS METALLURGY

By John S. Marsh
Alloys of Iron Research
New York City

*Many of the 100* papers presented and discussed at the annual meeting of the American Society of Mechanical Engineers in New York City during the first week of December had direct bearing on preparation for war—which followed so quickly. Papers of strictly metallurgical interest were few, but some of the other sessions were not too far afield from Metal Progress. An example is the one on "Work Standardization", during which Dean C. C. Balderson of Wharton School of Finance and consultant to Leeds & Northrup gave an explanation of wage indices for the metal working industry, "designed to provide practical information for periodic wage adjustments . . . . " This was countered by L. C. Hill, vice-president of Murray Corp. of America, who presented the arguments for more money used by "unioneers", and summarized the difficulty of refuting them with wage indices and formulas. The unions themselves were then heard via H. J. Ruttenberg of Steel Workers Organizing Committee, whose topic was "Index of Wage Rates as a Factual Aid in Collective Bargaining". Discussers were drawn from the Department of Labor, the National Industrial Conference Board, and the U. S. Conciliation Service. Times have truly changed when an engineering forum listens to a discussion of labor problems by a labor leader!

Of considerable current interest was "Physical Properties of Brass Cartridge Cases", by R. S. Pratt, of the Bridgeport Brass Co. Workers in this field insist that the successful use of brass results from its relatively low modulus of elasticity and from its fairly wide range of elastic deformation, because the case must expand quickly to form a gas-tight seal with the breech wall, but must return to its former size after firing to permit removal of the case. Modern cartridge brass contains (nominally) 70% copper and 30% zinc of high purity. Use of the latter has resulted in brass of improved mechanical properties and greater deformability. Cast bars weighing 500 to 1000 lb. are hot rolled, the final size depending upon the case to be made. In some instances the rolled bars are machined (scalped) to correct thickness; in others, there is some cold rolling followed by annealing to produce a specified grain size. Disks are then cut and cupped, the last operation in the brass mill. Thus the "skeletons" remain for remelting, and the cups are sent to the cartridge manufacturer. In World War I, five or six drawing operations were required to produce a 75-mm. case; the same case is now made in only three draws. This improvement is ascribed only to increased purity of the alloy.

Another paper of distinct interest to the metallurgist was E. W. Wrage's (Globe Steel Tubes Co.) description of the Foren mill for rolling seamless tubes. This mill has achieved substantially continuous production by the use of straight-line methods, including automatic controls for nearly every operation. Unfortunately, no adequate description can be given in such a brief notice as space permits.

Readers of Metal Progress as long ago as July 1940 may remember an article by Maxwell Gensamer on "Static Crack Strength", and the subsequent correspondence which linked this property to the more scientific "technical cohesive strength". Consequently D. J. McAdam's thoughts on the subject were on the metallurgist's "must" list, but fate interfered; an unguaranteed abstract is therefore submitted: "Recently the author has found evidence incom-

patible with prevalent views regarding technical cohesive strength of metals. Some of this has been assembled for discussion, particularly on the criteria of fracture, and variation of technical cohesive strength with plastic deformation." Also on the session on Mechanical Properties of Materials was an investigation of full-size railroad axles by O. J. HORGER and H. R. NEIFERT, of the Timken Roller Bearing Co. They found a correlation between residual stresses resulting from heat treatment; namely, that high fatigue strength is associated with high residual compressive stresses on the surface, whereas residual tensile stresses on the surface resulted in the lowest axle strength. This conclusion is compatible with logic, and the practice of shot blasting cheeks of crankshafts to increase their endurance limit.

No such session is complete without a description of the latest gadget for testing engineers devised by A. V. DE FOREST; this time, together with A. R. ANDERSON (also of Massachusetts Institute of Technology) he described "A New Lateral Extensometer". Claims made are "a very high degree of sensitivity, simplicity, stability, and ruggedness". The principle used is the mechano-resistance effect — that is, the change of electric resistance with strain. Four strain-sensitive elements act as arms of a Wheatstone bridge; unbalanced resistance results from strain, which is indicated by a galvanometer accompanied by a control box. Not bad!

Another use of fancy apparatus was disclosed in a discussion of "The Mechanism of Cavitation Erosion" by T. C. POULTER of the Armour Research Foundation. He stated that "corrosion resistance, caustic embrittlement, steam erosion, cavitation erosion, gun barrel erosion, wire drawing, fatigue, penetration of gases into metals, penetration of liquids into metals, and creep of metals are phenomena which are so completely interrelated that it is impossible to arrive at a proper explanation of one without at the same time shedding considerable light upon the others." Cavitation erosion of gray cast iron was studied by the use of a magnetostriction oscillator to test the assumption that such erosion results from penetration of the metal "pores" by liquids, and their subsequent escape accompanied by some of the metal. According to this picture, the erosive action of water should be much greater than that of alcohol or ether and that of glycerol or liquid paraffin should be negligible. Such was found to be the case. Details of this investigation are surely worth careful study.

The concentration of interest here was devoted to caustic embrittlement, although the participants were mainly chemists. It is probably still safe to assume that the problem is to be solved by doctoring the feed water rather than by changing composition of treatment of the metallic materials.

Simultaneous sessions — unavoidable, but exasperating these days — prevent anything like complete coverage; consequently it is likely that other items of metallurgical interest have been missed. However, here are a few words about other activities of the M.E.'s:

The coveted Holley Medal was awarded to JOHN C. GARAND for the development of the rifle that bears his name.

Inspection trips included the power and building service equipment of an insurance company, a spring works, a brewery, a commercial testing laboratory, and a hotel.

A National Defense Forum was told by Brig. Gen. G. M. BARNES, of the Ordnance Department, that the U. S. Army has developed a 4.7-in. anti-aircraft gun capable of throwing shells into the sub-stratosphere. While no performance data were given, the general said that the Army is satisfied and that the gun is in production.

A little booklet produced by the National Inventors Council was available; it is called "How Inventors Can Aid National Defense" and lists under needs in metals and metallurgy:

Armor plate and machines for making it.
Metal coatings and surface hardening.
Metal extraction and manufacture.
Alloys.
Metallurgical furnaces, apparatus, and processes.
Extraction of metals from scrap.
Welding, brazing, and soldering.
Cutting tools.

(All-inclusive titles! Is it possible that the National Inventors Council could use, as a member, a prominent metallurgist?)

As stated in the beginning, the meeting took place before Pearl Harbor, but even so, the gaieties of other years were reported to be scarce; even before Dec. 7 there was too much work to be done.

Finally, it is a pleasure to acknowledge the valuable assistance of ELLIS BLADE without whose eyes and ears this report would have been even less comprehensive.

# WAR PRODUCTS CONSULTATION

## *Sheet Scrap in Cupola Charge*

### The Problem

*Posed by a Stove & Furnace Works on the Pacific Coast*

AT *THE PRESENT TIME* we are having difficulty in getting certain materials, and if at all possible, we would like to make use of the scrap which we have available in our manufacturing processes. Some of this is light steel sheet, ranging down to 30 gage, while the heavier material runs around No. 3 gage. A portion of it is galvanized, but the larger share consists of regular steel sheets from which our regular products are fabricated.

We understand that steel scrap is being used as a component in gray iron foundry mixture. It is our understanding that the heavier sections of steel scrap can be used in melting, but that the extremely thin pieces do not work out satisfactorily, since they burn in the melting process. However, we note in the book "Gray Cast Iron" by JOHN W. BOLTON, that thin steel scrap has been used successfully. The author, however, does not state how or where such material is being utilized.

We would be pleased to learn what would be the best manner of utilizing this steel scrap in the manufacture of our gray iron.

### The Suggested Solution

You undoubtedly realize that steel scrap in a cupola charge does not replace an equivalent amount of pig iron or cast scrap. In other words, steel would ordinarily be charged in a cupola in order to reduce the carbon and silicon content of the hot metal, and therefore change the properties of the resulting castings. It may be that the castability, machinability and other properties of the castings you intend to make would not permit the use of any sizable percentage of steel scrap in the cupola charge.

If, however, this has properly been considered, the best form in which to charge the black sheet scrap would be as a tightly compacted bundle. Sheet scrap is bundled in this manner prior to remelting in an openhearth steel furnace. Fairly high pressure in hydraulic presses is required for such bundling. Some foundrymen have been able to handle some light sheet in the charge, without briquetting or compacting, by using a "soft blast" — that is, a minimum air-to-coke ratio.

It is suggested that the services of a professional metallurgist in your district be obtained, one who has had practical experience in foundry production as well as theoretical knowledge. Cast iron is one of the most complex among metals, and no book, article or letter can do more than point out the general principles upon which to build. There are, for example, many books on medical practices, yet it usually is smart to get a doctor!

### Critique by H. BORNSTEIN

*Chief Metallurgist*
*Deere & Co., Moline, Ill.*

The suggested solution is a good one.

The baling of sheet steel scrap has come into rather general use during the past few years. Many foundries are using these bales or bundles to good advantage in their cupola mix. Their *density* is important and this can be controlled by the pressure used in the hydraulic presses. Some foundries are specifying a minimum density of 30%.

Another important item is the *size* of the bundle. Smaller sized bundles are required for cupola charges than for openhearth furnaces. When the bundles are too large there is a tendency for hanging up in the cupola.

Where the bundles are of the proper size and are properly compressed, they can be used in the cupola charge instead of other types of steel scrap. Of course, when steel scrap of any sort is used in the cupola charge, the composition must be figured and suitable additions made in order to secure the desired analysis in the cupola metal.

In these days of shortages of various materials, it is necessary to make many changes in the cupola raw materials. A change in one portion of the charge usually means adjustment of the balance of the charge. The manufacturer must use materials which are readily available, and considerable study is required to obtain the desired quality of metal. This is the problem of the foundry metallurgist.

# MOLYBDENUM HIGH SPEED STEELS & THEIR HEAT TREATMENT

By Leonard C. Grimshaw
and Ray P. Kells
Metallurgists
Latrobe Electric Steel Co.

*During* the last five months, tool users and tool makers have become tremendously interested in molybdenum high speed steels. This is because General Preference Order M-14 issued June 11, 1941 by the Office of Production Management, and amendment effective October 28, 1941, requires each user to purchase at least three times as much of the molybdenum type high speed (known as "Class A") as of the tungsten type ("Class B"). The molybdenum type is defined as toolsteels containing over 3% molybdenum but not over 7% tungsten, whereas anything containing over 12% tungsten (and 0.55% carbon) is the tungsten type.

Many tool makers and tool users are apprehensive, as they are thus forced to abandon their old and familiar steels of the 18% tungsten type, and to use something new in their place. We hope in this article to allay this fear, and to explain how tools of molybdenum steel may be properly heat treated — because if they are properly heat treated they will assuredly be found to be equal to, or better than, tungsten high speed steels.

First, let us emphasize one point. The molybdenum steels are not new, and are not hurriedly thought up "substitutes". The fact that molybdenum could be used to replace tungsten in high speed steel was recognized 40 years ago by Taylor and White, the first proponents of high speed cutting, but in those days molybdenum was costly. The tungsten shortage of World War I, and lower prices for molybdenum, started development work on the new steels that was brought to fruition about 1930, as proved by a publication by S. B. Ritchie in *Army Ordnance*, July 1930, and by a later paper in *Transactions* of the American Society for Steel Treating, October 1932, by J. V. Emmons. By 1934 commercial heats were being made by several steel companies, so molybdenum steels were out of the laboratory 15 years ago, and getting put through their paces in industrial use.

These steels showed their value from the start, and by 1940, one quarter of all high speed steel used was molybdenum type! It usually takes 10 or 15 years for a good new steel to gain full recognition and acceptance. The molybdenum steels were going through this period, when along came this national emergency and accelerated their acceptance.

The steels *are* good, and it takes only a full understanding of their heat treating characteristics to get them to work at full efficiency.

*Analyses* — We are going to examine six basic types of molybdenum steels that have all been established and proven for several years. None of them is so new that there is any doubt about its capabilities.

The basic tungsten high speed cutting steel contains 18% tungsten, 4% chromium, 1% vanadium and 0.70 to 0.76% carbon.

Now the molybdenum steels contain about one part molybdenum for each two parts of tungsten displaced. The carbon content is selected for specific tool requirements, in the same manner that it has always been selected in the past for tungsten high speed steels. Speaking generally, the molybdenum steels require about 8 to 10 points more carbon than the tungsten ones, because they take an additional amount of carbon into solution when heated prior to hardening.

So the first change from 18-4-1 became steel No. 1 in Table I. This steel has been in commercial use for over eight years, and has proven its merits for use as twist drills, and many other cutting tool applications.

The next step was to eliminate the tungsten altogether, and put in 2% vanadium, and at the same time raising the carbon content in exactly the same way we raise the carbon when going from 18-4-1 to 18-4-2. This gives us steel No. 2 in Table I, which is a really fine steel, the full equal of 18-4-1. It answers practically every requirement for cutting tools, and makes an especially fine twist drill.

When extra red hardness was needed in tungsten steels, cobalt was added in amounts up to 12%. Such cobalt steels are used for deep cuts, and for chilled cast iron and manganese steels. Steels No. 3 and No. 4 in Table I are the molybdenum-cobalt steels that have taken their place over the past several years, and are the equal of the old cobalt high speeds in every way. Although tungsten cobalt steels were noted for the amount of decarburization that occurred during ordinary heat treatment, the addition of cobalt to these molybdenum steels does not cause decarburization over and above that expected of the 8% molybdenum base.

Out of the continual search that is always going on for better steels has come steel No. 5 in Table I, which is part tungsten, part molybdenum. This steel is a good steel, vastly superior to 18-4-1 for nearly all cutting purposes, and it has an advantage over straight molybdenum steel because it does not have any great tendency to decarburize during fabrication and heat treatment. When the molybdenum is on the low side of the range given, decarburization is kept at a minimum; when the molybdenum is on the high side of the range, decarburization takes place to about the same extent as in 18-4-1, but cutting efficiency is increased so that for all-round work the steel performs on the average much better than 18-4-1, and in many operations it is superior to 18-4-2 and 18-4-3. Perhaps the greatest advantage now is that you can purchase the steel in quantities actually required and still keep within the governmental restrictions.

If for some purposes a more abrasion resistant steel is desired, the carbon may be raised and 3% (or even 4%) vanadium added, as in steel No. 6 in Table I. The tough tungsten-molybdenum base of this steel is effective; therefore steel No. 6 is not brittle in service, as might be thought from the carbon and vanadium content.

**Table I — Analyses of Typical Steels***

| Steel | C | W | Cr | V | Mo | Co |
|---|---|---|---|---|---|---|
| No. 1 | 0.72 to 0.82 | 1.30 to 2.00 | 3.75 to 4.25 | 0.90 to 1.30 | 7.75 to 8.75 | ...... |
| No. 2 | 0.85 to 0.92 | ...... | 3.75 to 4.25 | 1.60 to 2.00 | 7.50 to 8.50 | ...... |
| No. 3 | 0.76 to 0.84 | 1.50 to 2.00 | 3.75 to 4.25 | 1.15 to 1.35 | 8.00 to 9.00 | 4.50 to 5.50 |
| No. 4 | 0.76 to 0.84 | 1.50 to 2.00 | 3.75 to 4.25 | 1.15 to 1.35 | 8.00 to 9.00 | 7.00 to 8.00 |
| No. 5 | 0.82 to 0.90 | 5.00 to 6.00 | 3.75 to 4.25 | 1.40 to 1.70 | 3.50 to 5.50 | ...... |
| No. 6 | 1.10 to 1.20 | 5.50 to 6.00 | 3.75 to 4.25 | 2.80 to 3.20 | 5.00 to 5.50 | ...... |

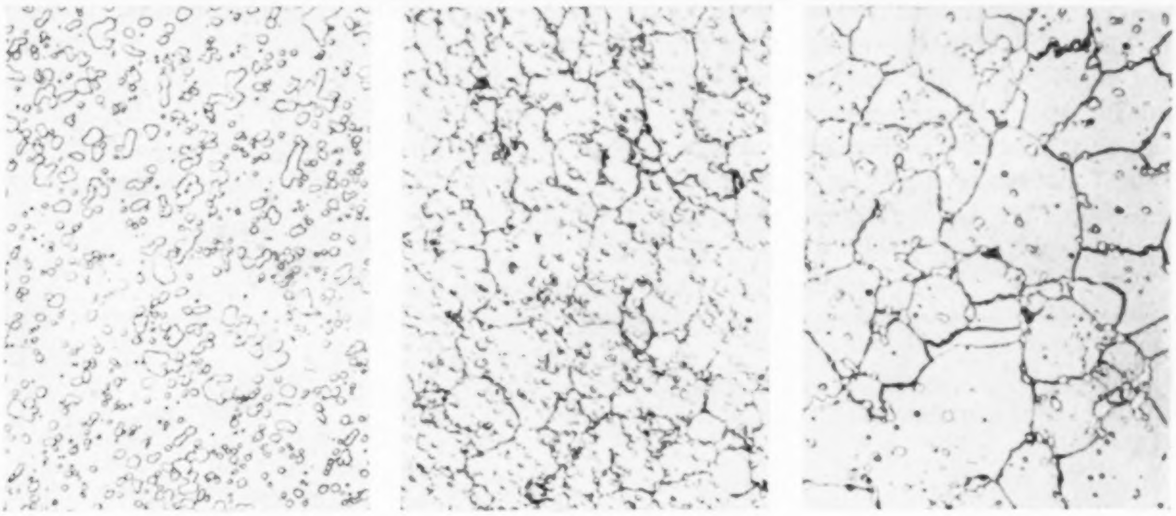
*The wide spread between upper and lower limits of each element is intended only to show the type of steel. Melting ranges of any manufacturer are much narrower.

**Table II — Proper Heat Treatments (° F.)**

| Steel | Preheat | Harden | Draw |
|---|---|---|---|
| No. 1 | 1400 to 1450 | 2200 to 2240 | 1025 to 1075 |
| No. 2 | 1400 to 1450 | 2200 to 2240 | 1025 to 1075 |
| No. 3 | 1400 to 1500 | 2200 to 2240 | 1025 to 1075 |
| No. 4 | 1400 to 1500 | 2220 to 2260 | 1025 to 1075 |
| No. 5 | 1400 to 1500 | 2240 to 2280 | 1025 to 1075 |
| No. 6 | 1400 to 1500 | 2240 to 2280 | 1025 to 1075 |

*Prevention of Decarburization* — The molybdenum steels are good. They were displacing tungsten steels on their merits. Are

*Fig. 1 — Microstructure of Standard 18-4-1 High Speed Steel at 500 Diameters After Nital Etch. Analysis: 0.72% C, 17.93% W, 4.14% Cr, 1.09% V*



| Underheated (Oil quenched from 2200° F.) Rockwell C-65 | Properly heated (Oil quenched from 2340° F.) Rockwell C-65 Grain size 11.0 | Overheated (Oil quenched from 2425° F.) Rockwell C-65 Grain size 6.5 |
|---|---|---|

there any drawbacks to their use? We will be honest, and say that with the possible exception of steel No. 5, they decarburize more easily than 18-4-1, and are all more susceptible to grain growth.

These are not serious drawbacks. Decarburization can be prevented by using salt bath furnaces, or furnaces with suitable atmospheres, or by coating the tools with borax or with one of the commercial paints that are suitable for the protection of molybdenum steels.

Salt bath furnaces are usually complete in themselves, consisting of the pre-heat, high heat, and quench baths. They furnish full protection against decarburization in any kind of high speed steel. Quenching is done in the salt quenching bath at about 1100° F., and this quenching bath removes the high temperature salt from the tools, so that there is scarcely any cleaning problem.

As for atmosphere furnaces, there are several on the market that generate their own atmospheres. The CO content usually runs about 34% with only a trace of $CO_2$. Such furnaces will harden high speed steels of all kinds with no soft skin.

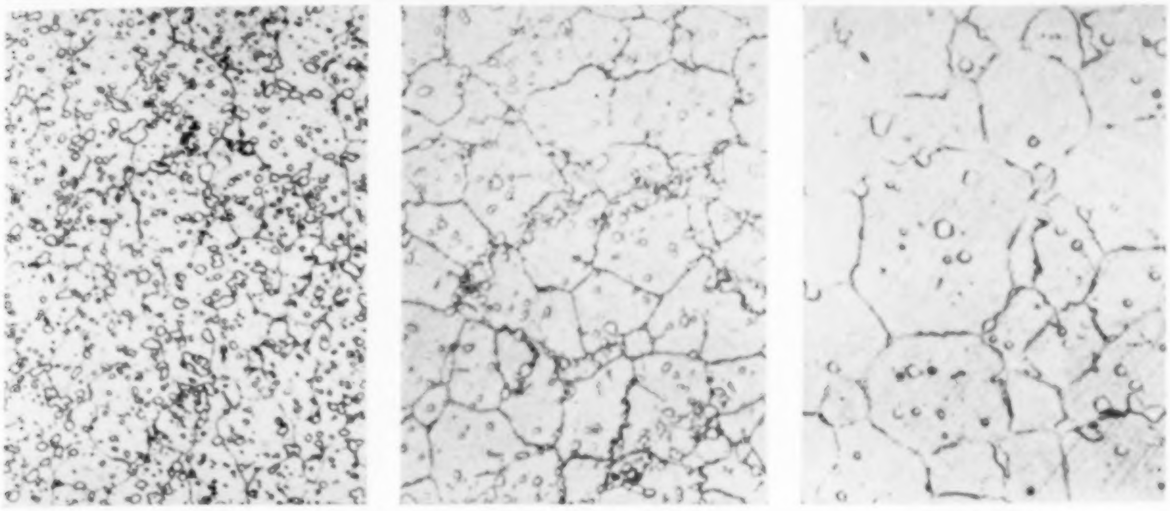
Muffle type furnaces harden a great deal of tungsten high speed steel successfully. The muffles contain neutral atmospheres created by coke gas, propane, natural gas, or manufactured gas. Such furnaces may be heated by gas or electricity. In general, the CO content should be about 2% higher for molybdenum steels than for 18-4-1. Although these atmospheres vary considerably, one that would be typical consists of 9% CO and 4% $CO_2$. In any such furnace, steel No. 5 may be hardened satisfactorily (except in the case of fine pointed tools, such as thread chasers) but the other molybdenum steels will decarburize somewhat unless coated.

A large amount of 18-4-1 has been hardened from old type semi-muffle furnaces that do not have a controlled atmosphere. If we wish to use one of these furnaces for molybdenum steels, we may do so if we coat the tools.

Before any coating is applied, the tool must be clean, entirely free from oil or grease. One frequently used coating is made by dipping the tools into a saturated solution of borax in water, that is heated to between 150 and 180° F. Tools dipped into this warm solution will dry when removed, and be covered with a thin powdery film of borax that will not rub off if the tools are handled with moderate care. Powdered borax may be lightly sprinkled on tools heated to between 1200 and 1400° F. if desired, but care must be taken not to use too much borax, or the excess will "pop off", or later drip off, and so eat into the furnace bottom. In extreme cases, too much borax will cause blisters on the surface of the hardened tools.

When borax is used, hardened tools will be

*Fig. 2 — Microstructure of Type 1 Molybdenum High Speed Steel.*
*Analysis: 0.81% C, 1.64% W, 3.87% Cr, 1.04% V, 8.07% Mo*



Underheated (Oil quenched from 2120° F.) Rockwell C-65.5 | Properly heated (Oil quenched from 2220° F.) Rockwell C-64 Grain size 9.9 | Overheated (Oil quenched from 2325° F.) Rockwell C-61 Grain size 5.0

found coated with a thin layer which must be removed with a wire brush, sand blast, or 10% solution of acetic acid. This surface residue will not be so hard and glassy if boric acid flakes, instead of borax, are used for making up the warm solution into which the tools are dipped.

There are at least three commercial coatings, or paints, that are advocated by their manufacturers for the prevention of decarburization in molybdenum high speed steels, and they do give good protection.* They do not fuse, or run, at the temperatures used, and therefore do not affect the furnace hearth. They may be applied to the cold tools by brush, by spray, or by dipping. Allow the coating to dry before placing the tools in the pre-heat furnace.

*Hardening and Grain Growth* — Now, assuming that we have taken care of decarburization, how do we guard against grain growth?

Anyone who has hardened 18-4-1 can harden molybdenum steels. The pre-heating at 1400 to 1500° F., the transfer to a high temperature furnace for hardening, the manner of quenching, and the drawing at 1000 to 1100° F., are all done in a similar way. A good tool treater well knows that at the high temperature used for hardening the steel should never be soaked excessively, but should be removed from the furnace and quenched very shortly after it is up to heat.

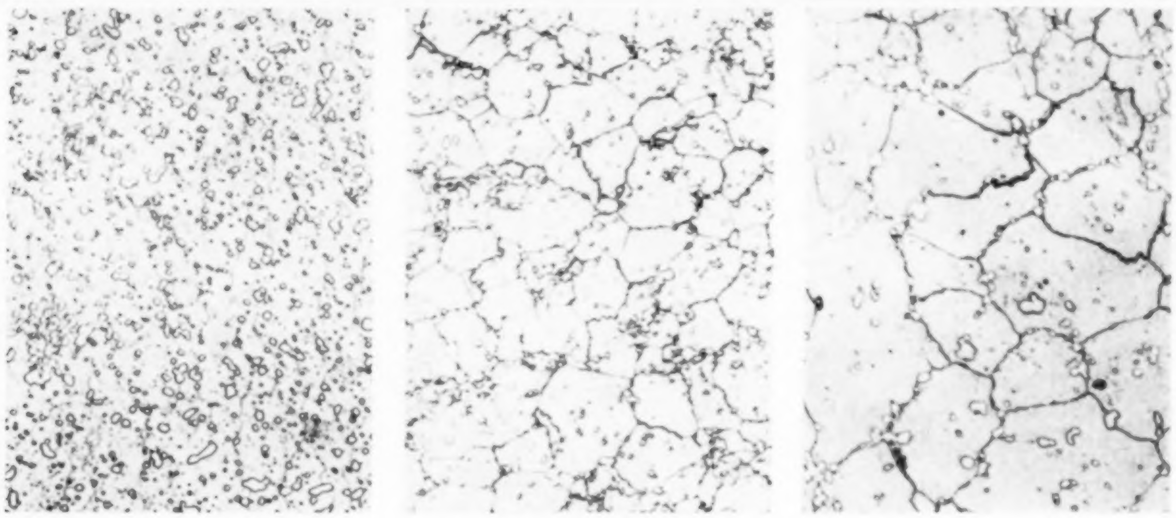
But whereas 18-4-1 may be overheated 75° F. and still make a reasonably satisfactory tool, overheating the molybdenum steels by such an amount will result in appreciable grain growth, and a tool that will probably be somewhat brittle. The temperature must, therefore, be under control. A good pyrometer is essential, because the molybdenum steels do not "sweat" like 18-4-1, and the correct hardening temperatures are 100 to 150° F. lower.

Table II (page 77) shows the correct preheating, hardening, and drawing temperatures to be used for the six types of molybdenum steel, when hardening is done from a muffle type furnace. If anyone were to compare these temperatures with those recommended by O.P.M.'s committee he would find them to be narrower in limits, as befits the narrower range of chemical analyses quoted in our six steels.

When a salt bath is used, lower the quoted temperatures 20 to 30° F. This last statement seems a little mystifying, but apparently tools truly reach the temperature of a salt bath, whereas they do not quite reach the temperature

*As noted in a document on "Heat Treatment of Molybdenum High Speed Steels" prepared by a special advisory committee to O.P.M. (see METAL PROGRESS, Sept. 1941, page 307) these trade names are: "No-Carb", made by Park Chemical Co., Detroit; "Sel-Car", made by National Copper Paint Co., Chicago; and "Ferritol", made by E. F. Houghton & Co., Philadelphia.

*Fig. 3 — Microstructure of Type 4 Molybdenum-Cobalt High Speed Steel. Analysis: 0.80% C, 1.72% W, 4.02% Cr, 1.21% V, 8.33% Mo, 7.47% Co*



| Underheated (Oil quenched from 2150° F.) Rockwell C-64.5 | Properly heated (Oil quenched from 2240° F.) Rockwell C-64 Grain size 10.2 | Overheated (Oil quenched from 2325° F.) Rockwell C-63.5 Grain size 6.2 |
|---|---|---|

of the thermocouple within the usual times employed in any muffle type furnace with a highly reducing atmosphere.

Quenching may be done in oil, salt bath, or air, in the same manner as tungsten high speed steels. Allow tools to cool below 200° F. and then draw, preferably before they are stone cold. Large and intricate tools liable to cracking may best be cooled only to 400° F. and then drawn, but in such a case they must always be re-drawn, because complete hardening transformation does not take place until the steels cool to room temperature after the first draw.

Multiple tempering is always recommended when good toughness is desired. About 2 to 3 hr. at the tempering temperature is sufficient for each draw. The greater part of the transformation of the austenite takes place when cooling down from the drawing temperature rather than at the drawing temperature, and is the reason why multiple tempering is preferable to one long draw.

The accompanying photomicrographs show what we may expect in structure and grain size when 18-4-1 and three types of molybdenum steel are underheated, properly heated, and overheated before quenching. The hardness figures below the photomicrographs, and those following in the text of this article, are what were obtained with the particular specimens examined. In practice, variations of a point above or below are to be expected even when using steels of almost identical analysis.

In Fig. 1 it will be seen that whether underheated or overheated, 18-4-1 as quenched has hardness of about Rockwell C-65, and that grain growth when overheated about 85° F. is moderate. When drawn at 1050° F., the hardness will remain at about C-65.

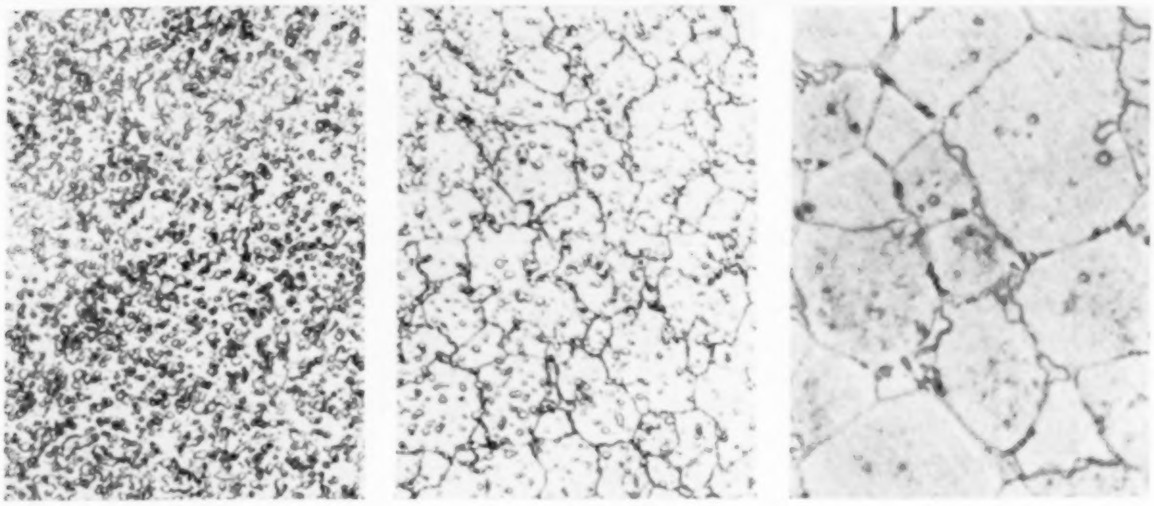
In Fig. 2 we observe the effect of underheating and overheating on steel of Type 1. The grains grow considerably when overheated about 100° F., and the Rockwell hardness as quenched drops to about C-61. The effect of a draw at 1025° F. will be to increase the hardness of the properly heated specimen moderately, to about C-65, but the hardness of the overheated steel will jump from C-61 to C-66 or higher. Needless to say, this may be too brittle for use because of the large grain size. Notice, also, that the quenched hardness of the underheated specimen is high, C-65.5, but will drop below C-64.5 when drawn at 1025° F.

Steel of Type 2 looks similar after identical heat treatments, and its Rockwell hardness is the same.

Steel of Type 3 is similar to steel of Type 4, illustrated in Fig. 3. In these cobalt steels there is less tendency to grain growth on overheating, and the variations in hardness are somewhat less noticeable.

Steel of Type 5 is illustrated in Fig. 4, and

*Fig. 4 — Microstructure of Type 5 Molybdenum-Tungsten High Speed Steel. Analysis: 0.85% C, 5.83% W, 4.15% Cr, 1.60% V, 5.41% Mo*



| Underheated (Oil quenched from 2125° F.) Rockwell C-65 | Properly heated (Oil quenched from 2250° F.) Rockwell C-64.5 Grain size 9.3 | Overheated (Oil quenched from 2350° F.) Rockwell C-62.5 Grain size 6.1 |
|---|---|---|

again variations in hardness behavior after quenching and after drawing follow the pattern of Types 1 and 2. A similar remark applies to steel of Type 6.

It may be stated as a general rule: If underheated, the hardness as quenched will be a little higher than normal, but will drop after the draw. If overheated, the hardness as quenched will be lower than normal, but will jump above normal after the draw. (By "normal hardness" is meant the hardness obtained by quenching from the correct temperature.) Thus hardness tests made after both the quench and the draw are an excellent guide as to whether the heat treatment has been correct, and make unnecessary the frequent use of the microscope and grain count.

After drawing, the microstructures of all these steels are very similar to that of 18-4-1, though to a trained eye they have a more acicular appearance.

The fracture of any molybdenum steel is not as fine and silky as that of 18-4-1, but appears duller or "chalky" and possibly coarser. "Dry" fracture describes it to many men. This is characteristic of the molybdenum high speed steels, but should cause no apprehension.

*Annealing* — Annealing of all six types is done at 1550° F., preferably in a closed pot or box, packed with dry sand or mica to which a few per cent of carburizing material has been added. Packing in cast iron chips will prove satisfactory.

Users of molybdenum high speed steels naturally wish to know how much decarburization to expect on annealed stock that they purchase from a steel mill. Maximum decarburization occurring after good annealing practice today is shown below, and steel is being regularly supplied to these limits. It will be seen that no more decarburization need be expected than when purchasing 18-4-1.

| | |
|---|---|
| ROUNDS | |
| 5/8-in. diameter and under | 0.015 in. |
| 21/32 to 1 1/4 in. | 0.020 |
| 1 9/32 to 1 31/32 in. diameter | 0.025 |
| RECTANGULAR SECTIONS | |
| Minimum dimension not exceeding 5/8 in. | 0.015 in. |
| Minimum 0.626 to 1.25 in., incl. | 0.020 |
| Minimum 1.251 to 1.999 in., incl. | 0.025 |

We sincerely believe that these molybdenum steels are good steels, and can be used anywhere that tungsten steels were used before. Many users of tungsten steels who have changed to molybdenum have had such satisfactory results that they have discontinued tungsten entirely. Remember, the steel maker has not had to rush research on these steels because of the tungsten shortage; it had been done carefully and painstakingly long before this emergency arrived. So we can only suggest that these steels be given a fair trial, and we know they will give very satisfactory results.

# CONSERVATION OF LEAD & ITS SUBSTITUTION

By Advisory Committee to OPM
on Metals and Minerals
(Draft by H. W. Gillett
Battelle Memorial Institute)

*In the spring* of 1941 is was considered that lead was plentiful and that it could be used freely to substitute for copper, zinc and aluminum and for tin, if necessary. It has been used for such substitutions and this, in addition to an unusually large demand for its conventional uses plus, perhaps, some "protective buying", has now resulted in a shortage. [Date of the report is Nov. 18, 1941.]

## Supply

The domestic lead supply of the United States comes from established mines. No important new ore bodies have been brought into United States production in the last 30 years. Some deposits in central Idaho, difficult of access, have been worked intermittently, and at higher prices a small ore increase might perhaps come from this locality and from Montana, Colorado, Arizona and Utah.

Most domestic mines are operating on a five-day week. A six or seven-day week would substantially increase domestic lead production over the 470,000 short tons calculated as the present annual rate of production from our own ore. Smelting and refining capacities are, in the opinion of experts, adequate to handle the increase.

There is general agreement among the experts consulted that production can be stimulated by an increased price for pig lead, both foreign and domestic. Regardless of what inducements are necessary, the bald fact stands out that the domestic lead producing facilities are not being used to capacity. Whatever steps are necessary to reach capacity production should be taken. If capacity production is not enough, further expansion of facilities should be considered.

*Secondary lead* [demolition scrap and junked articles] is an important factor in the trade. Much of the metallic lead used in storage batteries is secondary lead, chiefly itself from old storage batteries. Part of this reclamation is by small operators whose output does not get into the statistics. New lead, converted into red lead and litharge, is used in large amounts for the pasting material to fill the grids in the storage battery plates.

Little secondary lead is refined to "soft" lead; most of it is recovered as antimonial lead for batteries and cable sheath, or as more complex alloys, such as babbitt, solder and type metal. Some of the ores are smelted to antimonial lead.

Lead recently made available for use is tabulated at the bottom of the next page. The data for the years 1939 and 1940 are from U. S. Bureau of Mines "Minerals Year Book, 1940"; for 1941 are estimates by the Office of Production Management.

## Normal Consumption

In normal times the distribution of uses for lead runs about as follows:

| | | | |
|---|---|---|---|
| Storage batteries | 30.0% | Calking for pipes | 2.5% |
| Pigments | 20.0 | Bearing metals | 2.0 |
| Cable sheath | 12.0 | Type metal | 2.0 |
| Building | 8.0 | Automobiles | 1.5 |
| Ammunition | 6.0 | Terne plate | 1.0 |
| Tetra-ethyl lead | 5.0 | Castings | 1.0 |
| Foil | 3.0* | Miscellaneous | 3.0 |
| Solder | 3.0 | | |
| | | Total | 100.0% |

*Nearer 10% at the moment.

The ban on passenger automobiles will help a little in decreasing the need for lead in *storage batteries*, but not much, because old cars will be kept running and their batteries replaced, instead of buying a new car containing a new battery. Military vehicles, airplanes and submarines require storage batteries, so the total lead requirement for batteries is not likely to decrease. Because of a tight situation in antimony, the antimony content will be held down, which means that the lead content of the battery will be correspondingly greater.

*Pigments* take much pure, primary lead, so they use the most new lead. In 1940, 8.4% of the total lead used was as white lead, and 7.6% as red lead and litharge.

White lead is recognized as a durable paint. It is, however, not the only good white paint; temporary use of other white pigments, would entail no irreparable loss. Unfortunately, zinc oxide and lithopone are at least equally scarce. Titanium oxide ultimately may relieve the white lead situation; until that time arrives, the titanium pigments are probably the scarcer. The shortage of galvanized sheet makes it important that hitherto unpainted structures, formerly made from galvanized sheets, be painted; so the total requirements for pigments are up.

Red lead is used as a priming coat for structural steel, protecting it in storage, shipment and erection. Red lead is a good undercoat for other paints as well. The red lead coat has a definite functional use — that of corrosion resistance. Iron oxide, either mixed with red lead or in combination with other pigments such as zinc oxide and zinc chromate, is a noncritical substitute.

Litharge is an essential material when used as a drier in paints.

The requirement for *cable sheathing* is up materially, due to electric transmission and telephone needs. For instance, the American Bureau of Metal Statistics shows that 102,825 tons of new lead was used in 1940 for cables, but 106,257 in the first eight months of 1941. Experts, broadly appraising the situation, consider that perhaps a 10% reduction in thickness of cable sheathing could be made without serious detriment to the cable, though the change in cable-covering technique would involve hardship, and it is a question whether the saving would justify it. [As shown in the article on page 54] the shortage of copper forces the retention in service of power and communication cables that would, under ordinary economic conditions, be due for replacement. Even though inefficient, these old cables have to be kept in service. (Similar conditions obtain in the building industry.) On the one hand, this reduces the amount of new lead for new construction, but on the other it reduces the amount of secondary lead coming back for recovery. It is estimated that, instead of the usual 35,000,000 lb. of lead annually reworked from telephone system scrap, in the coming year this will fall to about 30,000,000.

Use of lead in the *building trades* is increasing because of copper scarcity. Lead pipe is being used instead of copper or brass pipe. Sheet lead is used for flashings, roofing and gutter linings. Lead is also used as a cushion for foundations. Lead house piping is hardly substitutable, but it can be made with thinner walls when suitable lead alloys are used instead of soft lead. Replacement, after fail-

**Lead Available in U. S. (Short Tons)**

| Source | 1939 | 1940 | 1941 |
|---|---|---|---|
| Refined lead | | | |
| From domestic ores | 420,967 | 433,065 | 470,000 |
| From foreign ores | 63,068 | 100,114 | 130,000 |
| From scrap | 29,011 | 16,588 | |
| Total refined lead | 513,046 | 549,767 | 600,000 |
| Alloyed lead (from scrap) | 163,937 | 214,097 | 150,000 *(a)* |
| Imports of pig lead | 7,139 | 151,568 | 336,000 *(b)* |
| Exports | −74,392 | −49,079 | |
| Total available | 609,730 | 866,353 | 1,086,000 |
| Refinery stocks, approximate | 200,000 | 100,000 | Nil |

Notes: *(a)* A fair reservoir of lead scrap probably exists, for total secondary lead in 1936 was 262,900 tons and in 1937 was 275,100 tons. However the figure 150,000 is reasonable, for articles are usually scrapped only when replacements are available.

*(b)* 150,000 tons bullion from Mexico, 96,000 from Canada, 48,000 from Australia, 42,000 from Peru.

ure, of a less durable material used as a substitute for lead requires too much expensive tearing up and suspension of services.

However, the comment has been made by one expert that "municipal building codes are notoriously wasteful of all materials used, lead included." It is understood that the Engineers' Defense Board is planning a comparison of important municipal codes with the one adopted by the Federal Housing Board.

*Ammunition* — In the previous war there were large requirements of lead for shrapnel bullets. With the changing character of war, shrapnel is little used. On the other hand, the production of machine-gun bullets is up enormously, and these bullet cores are weighted with lead, so the ammunition requirements will be up sharply. However, most experts figure that all the direct defense uses, lumped together, will not require more than 20% of the total available lead. [Note: These estimates were made prior to Pearl Harbor.]

As tank linings and other uses in *chemical equipment*, the corrosion resistance of lead is very useful and this use is, at the moment, nonsubstitutable.

*Calking* of pipe joints with lead in underground service permits the joint to remain tight despite settling of the ground, as the soft lead permits movement. Cement calking is prone to crack and produce leaks.

Use of *terne plate* has increased, as it is a substitute for galvanized steel for roofing and the like, and for tinplate in the making of cans for other than food products.

Scarcity of zinc, and particularly of aluminum for alloying use in zinc, has forced a large increase, five-fold or more, of lead-base *die castings* to replace zinc-base die castings, partly for ornamental gadgets on automobiles (which application will be stopped incidentally to the stopping of use of "bright work") but partly for functional parts, fuel pumps, hydraulic brake parts, and the like in which, however, they are not as good engineering materials as the zinc-base die castings.

Lead serves as a substitute for tin and aluminum in *foil* and *collapsible tubes*. The statistics do not indicate an increase in the use of lead for foil, yet one expert estimates the present use in foil as three times that of 1940, and another puts the present demand at around 100,000 tons a year!

*Bearing metals, type metal,* and *solder* are relatively small but important uses for lead. The lead-base bearing metals, as now applied in very thin coatings, serve where tin-base babbitts were formerly used and conserve the still more strategic tin. Copper-lead alloy bearings will be used in greater quantities as the aircraft engine program expands. Type metal is a revolving fund, the metal being reused and brought up to composition by small additions of new metal. A back-log of old electrotype plates in storage in many printing plants could be called upon at need; so the metal requirements of the printing industry are very small. Solder is one of the major uses of tin, and proper effort in this situation is to restrict the use of tin, even though this requires more lead, since the high lead, low silver type of solders appears to be the only practical substitute for lead-tin solders. [Automobile radiators consume a large fraction of the solder; this use will sharply decrease.]

## Conservation

Pending a suitable increase in the supply, it appears that lead can be saved by:

1. Limitation of the use of lead foil.
2. Substitution of other pigments for white lead as fast as substitutes become available (or possibly limiting the use of all white pigments).
3. Reduction of cable sheathing thickness.
4. Elimination of ornamental die castings and gadgets.
5. Restrictions in building uses and revamping of building codes.
6. Substitution of asphalt paint or the like for some uses of red lead.
7. Reduction in amount of lead per storage battery.

Such conservation and substitution measures might save a total of some 10%, or around 100,000 tons annually, as soon as they can be put into effect and ultimately, perhaps, up to 15 or 20% when all have been carried to the limit.

One expert comments that because of the large number of small uses for lead and the importance of the large uses, restrictions on the use will entail considerable hardship. Moreover, substitution is difficult, so curtailment of the less essential uses is called for, but no huge curtailment is feasible. Control of lead scrap, scheduling of deliveries to avoid frozen stocks, and "simplified practice" to avoid large inventory stocks in the hands of distributors, appeal to this expert as the logical methods to improve the situation, in the absence of much opportunity for substitution. *(Continued on page 118)*

# CORRESPONDENCE AND FOREIGN LETTERS

## Rapid Sorting of Small Castings

East Pittsburgh, Pa.

*To the Readers of* Metal Progress:

The problem of unscrambling a shipment of several thousand small conduit fittings was recently put up to the writer. It was known that some of them had been properly heat treated, and some improperly, or not at all. Mixing of lots had previously occurred more than once at the foundry, and it was desired to set up a quicker method of separation than grinding a small spot and testing each piece for hardness.

It took about an hour and a half to set up the apparatus shown in the accompanying view. Once the test was set up it required about 3 or 4 sec. to test each piece. Can you match this on any hardness tester? There was a further consideration noted above, that the manufacturer had run into this same trouble several times before and wanted an apparatus which he could keep on hand for use when necessary.

*Electrical Device Assembled of Standard Laboratory Equipment for Sorting Treated From As-Cast Conduit Fittings*

The device was built by hooking up three pieces of standard laboratory electrical apparatus (oscillograph, ammeter, and variac) and winding two small hollow coils of fine wire.

The test was based on the balancing of magnetic fields in the two coils. When the properly treated casting was placed in a coil of wire carrying alternating electric current, the magnetic field was increased more than when the untreated iron was tested. A straight line on the oscillograph window indicated that the magnetic fields were the same in both coils.

The method can of course be used to sort all kinds of small steel or iron parts which have different effects on a magnetic field. It is only a variation of devices, quite highly perfected, for testing the homogeneity of strip and tubing.

C. S. Williams
Research Laboratories
Westinghouse Electric & Mfg. Co.

## Multiple Tempering of High Speed Steel

Melbourne, Australia

*To the Readers of* Metal Progress:

I have been interested in reading two papers recently published by the A.S.M. dealing with surface studies of heat treated 18-4-1 high speed steel. One is by W. A. Schlegel in September *Transactions* entitled "Surface Carbon Chemistry and Grain Size of 18-4-1 High Speed Steel", and the other is by J. G. Morrison in the June issue. Its title is "Some Surface Studies on Treated High Speed Steel".

Both investigators found that in the great majority of heat treating atmospheres, surface *carburization* actually occurs and some excellent photomicrographs were given showing the greater stability of the austenite on tempering, as a result of this increased carbon content. After tempering, the surface structures showed dark etching martensite needles in a white austenite matrix, and multiple tempering was found to be necessary in order to break down this austenite completely.

It is perhaps of interest to point out that rather similar conditions can be obtained around carbide segregates in the center of high speed steel bars. Particularly with the larger diameters, it is quite usual to see at low magnification, after hardening and single tempering, light and dark etching areas forming a definite pattern.

The dark areas show the usual structure of tungsten carbide particles in uniformly dark etching martensite. The lighter areas generally surround local concentrations of the carbide particles, and in some cases at high magnification we have found them to show dark needles in a light matrix, in every way similar to the structures described in the two papers mentioned. In the same way also this austenite can be completely transformed by multiple tempering.

Apparently slightly more carbon must be taken into solution in the immediate vicinity of the segregations of free carbides, and the short time does not permit diffusion. As a result in such regions the austenite is more stable and the typical mixed needle structure exists after a single tempering.

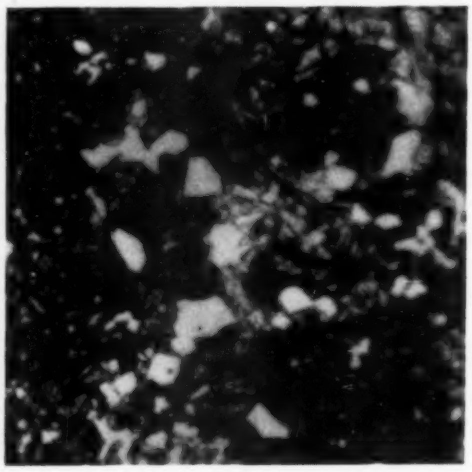
Two photomicrographs are attached which illustrate this point.

The above consideration seems of definite practical importance when it is remembered that in certain tools the center of the bar (where carbide segregations occur) forms the actual cutting edge.

J. G. Ritchie
Metallurgist
McPherson's Pty., Ltd.

*Conditions Near Center of Hardened $1\frac{3}{4}$-In. Bar of 18-4-1 at 1000 Diameters, Etched With 2% Nital*

Single Tempered; $1\frac{1}{2}$ Hr. at 1060° F. Light etching area around carbide segregate



Multiple Tempered; $1\frac{1}{2}$, 1 and 1 Hr. at 1060° F. Carbides in uniformly etching martensite

## Metals From Argentina

Buenos Aires, Argentina

*To the Readers of* Metal Progress:

The American demand for metals and ore, difficulties of supplies from overseas, and the inspiring example of Brazil where the exploitation of the Minas Geraes iron ore deposits is at last scientifically organized — all this has considerably increased Argentina's interest in mining. The Government has promised low-interest credits, not exceeding half a million pesos in each case, to prospectors and organizers of smaller mining enterprises; and the Ministry of War has made a thorough research into the hematite deposits in the province of Jujuy, at the northern tip of our country containing most of the mineralized areas. Some small production is consumed by local industry; for instance, some openhearth steel made from scrap iron and the glass industry consumes annually 700 tons of pyrolusite (manganese ore). However, beryl, lead, zinc and tungsten are of most interest to Americans.

Production of beryl (ore) has amounted to from 500 to 750 tons annually. Most of this was previously sent to Germany, but the consumption in the United States — largely for the production of beryllium metal and its alloys—has been rising rapidly, amounting to 182 tons in 1937, and 456 tons in

1939. Three-quarters of our beryl is produced by the Las Tapias mine in the province of Cordoba, about 350 miles northwest of Buenos Aires. Recently a small mill for the production of beryllium oxide concentrates, 90% pure, has been completed.

Tin has never been mined in nearly the quantity of our neighbor Bolivia, but the production has more than doubled between the years 1935 and 1940. Tin content of the ore mined in 1940 equalled 3,000,000 lb., but reduced 23% from 1939, mainly due to the gradual exhaustion of the Pirquitas mines in the province of Jujuy, although the property is now working the poorer minerals too, at least for the duration.

A moderate amount of tin metal is now produced by the South American Mining Co. in Buenos Aires; the current production of 895 tons annually is far below the plant's capacity of 1440 tons. Due to present shipping conditions, our own requirements of metallic tin must be supplied by ourselves.

Argentina is an important American source of valuable tungsten. Production of ore was 1054 tons in 1938, 1155 tons containing 76,521 lb. of tungsten metal in 1939, and 1250 tons in 1940. In the last mentioned year 253 tons of 68% $WO_3$ ore was sent to Japan, the balance to the United States. Half of the production comes from the Condores mine in San Luis province, due west of Buenos Aires.

Zinc and lead, however, are the most important products in tonnage, and it practically all comes from the Aguilar mine in Jujuy, owned by the St. Joseph Lead Co. National Lead Co., another United States corporation, owns and operates a lead smelter at Puerto Vilelas. Production in metric tons for the last three years of record are:

| | 1938 | 1939 | 1940 |
|---|---|---|---|
| Pig lead | 7,200 | 11,248 | 12,864 |
| Lead concentrate | 31,848 | 40,275 | 40,905 |
| Zinc concentrate | 29,496 | 42,262 | 66,384 |

The above figures show that zinc is now being produced at a rate the highest ever known in Argentina. Its tonnage will materially supplement that produced in other countries within the Western Hemisphere.

WALTER P. SCHUCK
Argentine Financial Service

## Proposed Phase Diagram Notation

NEW YORK CITY

*To the Readers of* METAL PROGRESS:

Phase diagrams for metallic systems are now so numerous that a uniform and elastic system of notation is becoming increasingly necessary. The matter has been discussed at some length by the group charged with the task of preparing the phase diagrams for the next edition of Metals Handbook, and some definite suggestions have been forthcoming. Before final action, however, and despite the unsuitability of the times for the fullest possible cooperation, it is felt best to submit the proposal to the widest possible metallurgical audience, with an earnest plea for criticism, additional proposals, or both.

In brief, it is proposed that:

1. All systems be indexed alphabetically, but that some latitude be permitted in the order of appearance of the elements on the actual diagrams. Thus, the iron-carbon system would be indexed as C-Fe, whereas it would be manifestly unwarranted to have the diagram itself appear in any position other than that demanded by Fe-C. In other words, both custom and industrial importance demand that the left end of this diagram shall represent 100% iron. Less clear cut cases are many; for most, alphabetical order of appearance would be the solution.

2. All solid phases are to be labeled in order of the Greek alphabet, starting with the left-most phase, *except* when this procedure deviates from international usage ($\gamma$Fe is a conspicuous example), and *except* when the structure is known to be identical with one having a widely accepted notation (*e.g.*, $\beta$ brass).

3. In addition to the Greek letter designating a single phase region, there shall be a subscript consisting of either the chemical symbols of the elements or their atomic numbers, and a number that defines precisely the crystal structure of the phase. (At first sight, such a system might appear unwieldy and superfluous, but the necessity of some such system becomes real when it is remembered that it then becomes possible to correlate the diagrams with etching tables, structure tables, and other such information.) The nature of the number for designating the structure would perhaps be based on the 230 possible space groups.

It is believed that the proposed system is one that fulfills the requirements of uniformity and elasticity, although it will have been noted that the concession to conventionality, as far as it goes, has seemed unavoidable. It would be a step forward, at least, to establish a rational system of notation, provided that the one finally selected is satisfactory to most of the workers in the field.

It is repeated that reader comment will be welcomed at the earliest possible date, addressed to the undersigned, who is acting in this instance for the Committee which includes Kent R. Van Horn, Chairman, and F. W. Rhines.

John S. Marsh
Alloys of Iron Research

## Creep Strength of 18-8 Ti

Ugine, Savoie, France

*To the Readers of* Metal Progress:

The phenomenal development of steels of the 18-8 type and their remarkable resistance to oxidation naturally leads to the possibility of application to service at high temperatures. However, while there is an abundant literature concerning their resistance to corrosion, which is the essential characteristic and *raison d'etre* of these steels, relatively little exists as to their mechanical strength at high temperature, that is to say, the results of creep tests. Such tests have been made mostly on steels whose chemical composition is more especially designed to obtain resistance to oxidation or heat.

It might be interesting to note that the addition of titanium, which is widely used for preventing intergranular corrosion in 18-8 steels, also appears to have a favorable influence on high temperature strength of these steels. This is shown by results obtained by M. de Lacombe when comparing a group of casts of 18-8 steel (0.10% C, 9% Ni, 18% Cr) without titanium with another group cast from the same steels containing an addition of 0.4% titanium.

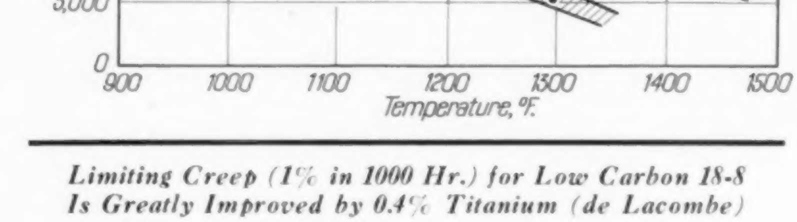
Samples were submitted to creep tests for 25 to 35 hr. at temperatures between 1000 and 1500° F. under loads of 5500 to 21,000 psi., at a rate of elongation which extrapolated to 1% per 1000 hr.

The results are summarized in the attached graph giving this limit as a function of the test temperature.

It can thus be seen that the temperature corresponding to this limiting creep is about 200° F. higher for heats with titanium, and the relationship of the loads at the same temperature is approximately 2 to 1. Several long-time tests showed furthermore that the differences thus established for a 35-hr. test do not diminish greatly during 300 to 500 hr.

Likewise, ordinary 18-8 steel without titanium appears less stable at high temperature. Tensile strength (tested cold) increases after cooling, with a decrease in elongation, reduction of area and ductility; this change in mechanical properties after a long stay at high temperature is accompanied by a carbide precipitation essentially intergranular in nature, which becomes visible under the microscope when the soaking temperature reaches 1100° F. and increases in amount as the temperature is increased. Under the same conditions the steels containing titanium show no carbide precipitation. They therefore appear clearly preferable to the ordinary 18-8 for uses at high temperature.

Albert M. Portevin
Consulting Engineer
Bessemer Medalist




*Limiting Creep (1% in 1000 Hr.) for Low Carbon 18-8 Is Greatly Improved by 0.4% Titanium (de Lacombe)*

# CORRESPONDENCE AND FOREIGN LETTERS

## Mass Production of Nitrided Tank Parts

CHICAGO, ILL.

*To the Readers of* METAL PROGRESS:

An unusual heat treating operation is the nitriding of tractor pins for tank treads as carried out in mass production at the Campbell Wyant & Cannon Foundry Co., Muskegon, Mich. Loads of 12,000 lb., containing 10,000 track pins, are being nitrided to a depth of 0.025 to 0.030 in. A typical load is shown in the accompanying illustration.

The track pins are 9½ in. long by ¾ in. dia. and are used to tie the tractor shoes together, in much the same manner as a hinge pin. Each tank requires 140 pins, 70 per side. The pins are of a modified nitralloy G steel having the following approximate analysis: Carbon 0.30 to 0.40%, silicon 0.30% max., manganese 0.40 to 0.60%, chromium 1.40 to 1.90%, molybdenum 0.15 to 0.25% and aluminum 0.90 to 1.40%.

Prior to nitriding the pins are heat treated by oil quenching from 1650° F. They are then drawn at 1300° F. This treatment results in the following physical characteristics: 123,000 to 145,000 psi. tensile; 15% elongation in 2 in., 45% reduction of area, and 45 ft-lb. min. Izod notched-bar test.

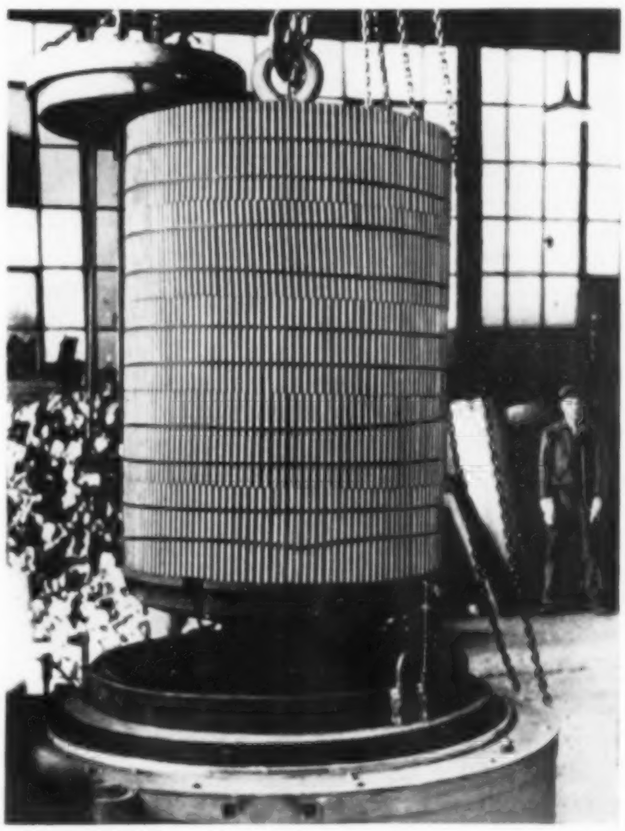
In preparing the load for the nitriding operation, a cylindrical fixture is used, visible in the background of the photograph, immediately back of the man. The bottom layer of pins is set on an alloy grid which rests in the bottom of this cylindrical fixture. This bottom layer consists of 2000 pins solidly packed, held together with steel banding. Successive layers are handled in the same manner, and when the five layers are completed, the load is lifted from the fixture and lowered into the furnace.

Nitriding is carried on in two Lindberg cyclone nitriding furnaces, equipped with alloy retorts 38 in. dia. by 54 in. deep. Self-sealing, insulated covers are provided, and ammonia is introduced through pipes extending through the cover, extending down alongside the charge to its very bottom. The furnaces are gas-fired, and are of the forced convection type in which heated air is circulated under pressure and at high velocities around the heat treating retort and back into the heating compartment. Such heating by forced convection promotes temperature uniformity.

The original installation was a single furnace, and another was added later on. In the period of approximately six months since installation, over 300,000 pins have been nitrided without the loss of a single pin. End-to-end runout specifications on straightness are 0.010 in. max. and no pins have been rejected due to warpage.

Loads are staggered between the two furnaces so that one heat is available at the middle of the week, and the next heat at the end of the week. A weekly production of 20,000 pins is therefore turned out.

Robert G. GUTHRIE
Consulting Metallurgist



***Six-Ton Load of 10,000 Pins for Tank Tracks Entering Nitriding Furnace for a Week's Stay. 300,000 pins without one reject for warpage***

## CORRESPONDENCE AND FOREIGN LETTERS

# Charpy Tests on Austempered 4140 Steel

BETHLEHEM, PA.

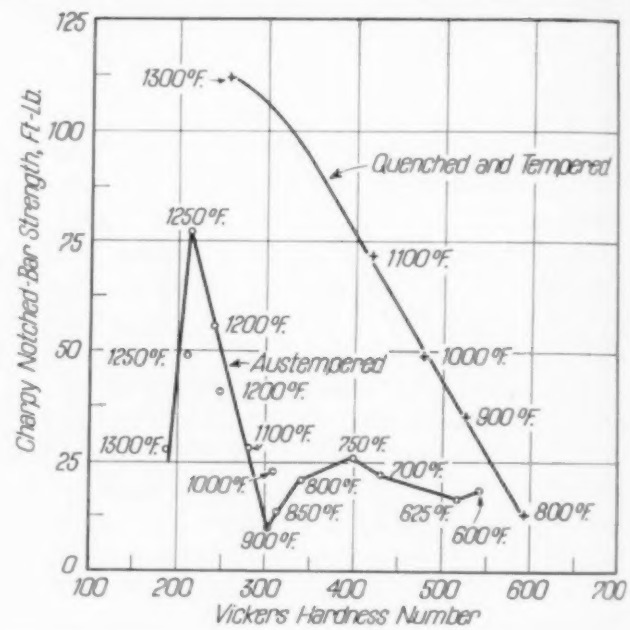
*To the Readers of* METAL PROGRESS:

Since the chromium-molybdenum steel S.A.E. 4140 is becoming more and more popular for defense purposes, especially for light aircraft forgings, it may be interesting and valuable to record some notched-bar tests on this steel after the samples have been given an austempering treatment. The work was done by the undersigned and submitted as a graduation thesis at Rensselaer Polytechnic Institute in 1940.

The steel, kindly supplied by the U. S. Steel Corp., analyzed 0.43% C, 0.78% Mn, 0.017% P, 0.024% S, 0.95% Cr, 0.20% Mo. From a single spheroidized bar, standard Charpy specimens were prepared and the V-notch cut with a very accurate 45° double angle milling cutter. Micro examination showed that the coating later to be mentioned actually did protect the surface during heat treatment — that is, no difference could be detected between the microstructure at the root of the notch and the center of the broken specimen.

After machining the specimens were oiled, coated with alundum cement ¼ in. thick, dried, and painted with several coats of water glass. Heating for normalizing was done while packed in cast iron borings (6 hr. at 1700° F.). The cement coating was then cracked off; subsequent heating for quenching (2 hr. at 1600° F.) was done in cast iron borings. Triplicate samples were quenched in molten metal at constant temperature and held well over the time for complete transformation, as shown on the "S" curve. Comparison samples, after quenching in cold oil, were again covered with cement before tempering.

Results are plotted in the graph; in most cases points are averages for three samples. Charpy figures for the austempered samples are unexpectedly low. Comparison with the "S" curve (METAL PROGRESS for October 1941, page 517) indicates that the structure of samples austempered at 1000° F. and higher consists of ferrite and lamellar constituent; their notch bar values are on a higher order than the other samples which are entirely of the acicular constituent, yet on a lower order than the notched-bar values of the samples quenched and tempered to sorbitic (non-lamellar) structure. At very high hardnesses, Vickers 540 or Rockwell C-50, the notched-bar figures approach each other, no matter whether the hardness is secured by austempering at a low temperature or by quenching and drawing.




*Charpy Notched-Bar Tests on S.A.E. 4140, Either Austempered at Indicated Temperatures, or Oil Quenched and Drawn as Noted*

The continuous change in the curve for quenched and tempered steel is in keeping with a continuous change in the structure as the tempering temperature increases. Granulation of the carbide particles has progressed far enough at 1300° F. to be easily visible. There seems to be good microscopic evidence associated with the marked change in toughness of the austempered specimens at about 900° F.; causes of the peaks at 1250° F. and at 750° F. can only be speculated about.


JOHN B. NEWKIRK
Student
"Loop" Training Course
Bethlehem Steel Co.

## PERSONALS

**Murray J. Goldwasser**, formerly instructor of powder metallurgy at Stevens Institute of Technology, is now with the Gibson Electric Co., Pittsburgh, doing research and testing of electric contacts.

New representatives appointed by Ajax Electric Co., Philadelphia: **William H. Addis**, in the southwestern territory with headquarters in Houston, Texas; **Otto P. Kossatz**, in the states of Kentucky and Indiana with the exception of the South Bend district, with headquarters in Indianapolis; the **C. B. Fall Co.**, St. Louis, Mo., in the states of Kansas, Missouri, Arkansas and southern Illinois.



**E. T. Bishop** has been transferred from Duncan Field, San Antonio, Texas, to Lowry Field, Denver, Colo., as supervisor of heat treating and welding.

**T. D. Sheppard** is now acting supervisor of the Scrap Control Department of Wright Aeronautical Corp.

**J. B. Henry, Jr.** is on leave of absence from Allegheny Ludlum Steel Co. to act as principal commercial specialist, Priorities Division, Office of Production Management.

**R. F. Flood**, formerly service engineer, Central Division Office, Chicago, for The Linde Air Products Co., is now assistant district manager in Detroit.

Transferred by General Electric Co.: **Joseph A. Cameron**, from the research laboratory in Schenectady to the laboratory of the Everett Supercharger Department in Everett, Mass.

**Victor R. Farlow**, formerly metallographer, Caterpillar Tractor Co., is now an instructor in the Engineering Defense Program at Cornell University.

**John L. Everhart**, formerly assistant director of research, U. S. Metals Refining Co., Carteret, N. J., is now engineer at the National Bureau of Standards, Washington, D. C.

**R. C. Dalzell**, technical advisor of the Baltimore Division of Revere Copper and Brass, Inc., has been elected president of the Baltimore Alumni Association of Tau Beta Pi, honorary engineering fraternity.

**Carl A. Boese**, formerly employed by Interstate Drop Forge Co., Milwaukee, in estimating and designing work, now has a position in the standards unit of the engineering department of Boeing Aircraft Co., Seattle.


# 5 KINGS *are better than a FULL HOUSE*

| *Product* | *Temp.* |
|---|---|
| C. H. C. Salt | 1150-1600° F. |
| Kwick Kase Salt | 1250-1600° F. |
| Klean Heat Salt | 1150-1600° F. |
| Nusal Salt | 1300-1600° F. |
| $K_2$ Reheat Salt | 1100-1700° F. |
| Park Kase 1 Salt | 1200-1700° F. |
| Park Kase 2 Salt | 1200-1700° F. |
| Park Kase 3 Salt | 1200-1700° F. |
| Park Kase 5 Salt | 1300-1700° F. |
| Park Kase 6 Salt | 1300-1700° F. |
| 117 High Speed Preheat Salt | 1300-1700° F. |
| 175 High Speed Hardening Salt | 1900-2400° F. |
| 100 High Speed Quench Salt | 1000-1300° F. |
| 28 High Speed Draw Salt | 950-1150° F. |
| 90 High Speed Casing Salt | 1000-1150° F. |
| $K_2$ Reheat Salt | 1100-1700° F. |
| $Al_1$ Salt | 375-1100° F. |

**No Carb Carbon Preventer**
**Lead Pot Carbon**
**Quenching-Oils**
**Pitch Coke-Charcoal**

**A FULL HOUSE is FINE in POKER but NOT in the HEAT TREATING DEPT.**

**Park PRODUCTS ELIMINATE BOTTLENECK DELAYS *by means of***

1. **Stock Shipments—*Same* Day as Ordered.**
2. **Uniform Shipments—*Laboratory* Control Guarantees *Batch* Uniformity.**
3. **Metallurgical Sales Engineers—Available for Advice when Needed.**
4. **Products Economical in Price and Use.**

Heat Treating **Park** Products since 1911

**CHEMICAL COMPANY**

**8076 MILITARY AVENUE DETROIT. MICHIGAN.**

# PERSONALS

**Bennett Burgoon, Jr.** has been appointed representative for McKenna Metals Co. at Rockford, Ill., following his resignation as mechanical engineer of the Railway Steel Spring Division, American Locomotive Co., Latrobe, Pa.

**Harry S. Toups, Jr.** has left his position at Tennessee Coal, Iron & Railroad Co. to accept a position as shell inspector in Thibodaux Boiler Works' 105-mm. shell plant in Thibodaux, La.

**Clinton C. Hudson**, formerly with the Glenn L. Martin Co. in Baltimore, is now chief chemist and metallographer for the Glenn L. Martin-Nebraska Co. in Omaha, Neb.

**W. L. Kennicott**, previously Los Angeles sales manager of McKenna Metals Co., is now at the head office and factory at Latrobe, Pa., in the management of sales and engineering.

**R. E. Bingman** has been appointed district manager for the Indiana territory by the Jessop Steel Co. of Washington, Pa.

**John G. Kura**, formerly associated with the Carnegie-Illinois Steel Corp. at Duquesne, Pa., has been named to the technical staff of Battelle Memorial Institute, Columbus, Ohio.

Appointed division metallurgist for cold-drawn products of American Steel & Wire Co.: **Edward M. Murphy**, formerly assistant to superintendent at the Company's Newburgh Wire Works.

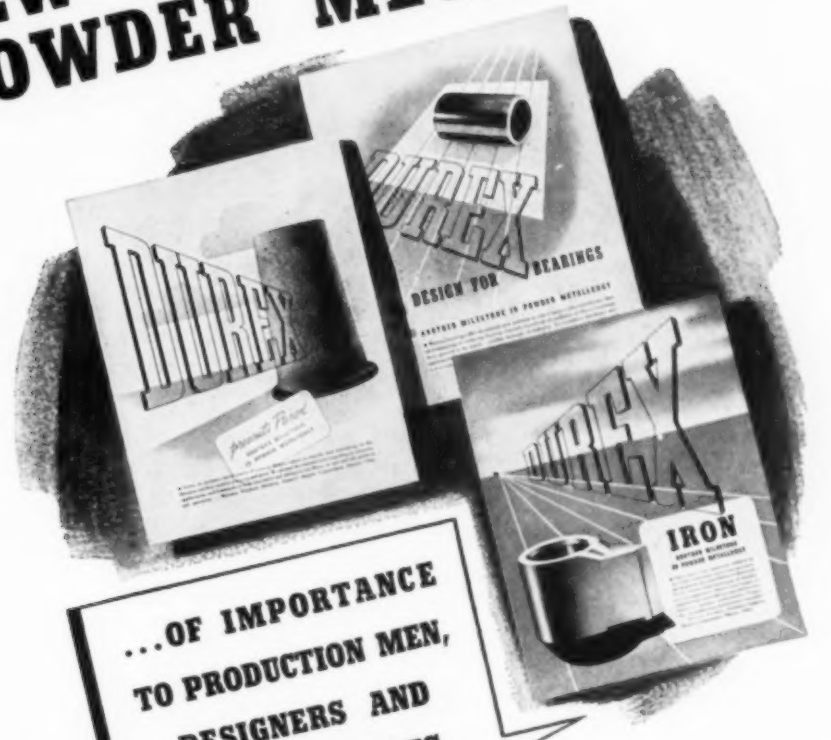
Transferred by The Linde Air Products Co.: **Joseph W. Jennings**, service engineer, from the Milwaukee to the Cleveland district office.

Promotions by Uddeholm Co. of America, Inc., New York City: **E. V. Enevik**, from vice-president to first vice-president; **Willy A. Olsen** to vice-president in charge of toolsteel sales; **E. W. Dutcher,** from assistant treasurer to assistant secretary; **James Owens,** to assistant treasurer.

**Charles F. Burrows** is now chief materials and process engineer at the Glenn L. Martin-Nebraska plant in Omaha.

First Lieutenant **J. E. Lindsay**, Chemical Warfare Service, United States Army, is now on leave of absence from his position as chief chemist for the National Radiator Co. and its subsidiary, Plastic Metals, Inc., and has been assigned to the Munitions Development Division, Edgewood Arsenal, Md.

# 3 NEW BULLETINS ON POWDER METALLURGY




...OF IMPORTANCE TO PRODUCTION MEN, DESIGNERS AND METALLURGISTS

A few Durex Iron parts, made by compressing iron powders in dies, then heating under precise control of temperature and atmosphere. Many costly and time-consuming machining operations are avoided, close tolerances are maintained, vital materials are conserved, and scrap material loss is completely eliminated.

● These valuable bulletins bring you straightforward engineering facts on three basic classes of products engineered by Moraine from metal powders: Durex Iron mechanical parts and bearings; Porex filters and diffusing plates; and Durex bronze oil-retaining bearings. *For designers,* they give facts on tolerances, shape and size possibilities and limitations. *For production men,* they suggest time and money-saving short cuts, show how Durex and Porex parts conserve materials, improve product performance, often do jobs never done before. *For metallurgists,* they contain helpful new information on physical properties, structures, and applications of Durex products . . . Durex Iron parts, for example, made without machining from scrap steel, replace, at low cost, parts conventionally machined from steel and iron, or die cast from such vital materials as zinc and aluminum. A request on your letterhead will bring you any or all of these bulletins without obligation.

*Porex Filters: (Form 101D)* *Durex Iron: (Form 102D)*
*Durex Bearings: (Form 103D)*

# MORAINE

*Pioneer in Powder Metallurgy*

MORAINE PRODUCTS DIVISION, GENERAL MOTORS CORPORATION, DAYTON, OHIO

# PERSONALS

**H. Theodore Sumsion** has left the employ of the U. S. Bureau of Mines at the Salt Lake Station to become metallurgical engineer for the Remington Arms Co. at the Utah Ordnance Plant at Salt Lake.

**Carter C. Higgins**, formerly export manager, Worcester Pressed Steel Co., has been made assistant general sales manager.

**George Stern** has resigned from his position as research metallurgist with the American Electro Metal Corp. of Yonkers, N. Y., to accept an appointment in the metallurgy division of the Armour Research Foundation, Chicago.

**Ray P. Dunn**, formerly metallurgist for Electro Manganese Corp., in Minneapolis, is now metallurgist for Emerson Electric Mfg. Co., St. Louis, Mo.

**Sidney Breitbart** has recently been promoted to the position of assistant metallurgist at the Aberdeen Proving Ground, Aberdeen, Md.

**Kenneth H. J. Clarke**, metallurgical engineer, the International Nickel Co. of Canada, Ltd., Toronto, has joined the staff of the Metals Controller, Wartime Industries Control Board, Department of Munitions and Supply, Ottawa, in the capacity of technical consultant.

**Harold W. Hanes**, formerly with American Rolling Mill Co., is now employed in the Materials Laboratory at Wright Aeronautical Corp., Cincinnati Division.

**L. J. Rausch** has been transferred from the Chevrolet Engineering Department at Flint, Mich. to the Chevrolet Aviation Department, Tonawanda, N. Y., as quality engineer on assembly.

**Russell Lowrey** has left the employ of the California Steel Treating Co., and is now consulting on heat treatment and metallurgy with offices at Bell, Calif.

**W. C. Dyer**, resident inspector of ordnance, has been transferred from W. C. Norris Manufacturer, Inc., Tulsa, Okla., to Texasteel Mfg. Co., Fort Worth, Texas.

**Ralph L. Wilson**, formerly assistant metallurgist for Climax Molybdenum Co. in Canton, Ohio, is now in the Alloys and Specifications Division of the OPM in Washington.

**R. A. Barr** has been made district sales manager in the Chicago territory for the Carborundum Co.

# Heating textbooks will have to be rewritten!

## A Basic Heating Principle has been EXPLODED!

**For years textbooks and heating authorities said it couldn't be done . . . *but it is being done!* . . .** In Iowa, one of the new Lindberg units requiring a space 6-feet wide by 10-feet long replaced eight older furnaces which took up a space 45-feet by 7-feet . . . . and turned out as much work in 8 hours as the eight older furnaces did in 16 hours!

**REDUCED STRAIGHTENING!** In Chicago, the new Lindberg heating principle cut straightening operations on worm gears from 95% requiring straightening to less than 2%.

**HANDLED TOUGH JOB PERFECTLY!** On another Chicago installation a complicated armament part which no equipment had ever been able to handle without serious distortion, has been heat treated for months by means of the new Lindberg heating principle without a trace of distortion.

**PROVED IN 97 INSTALLATIONS . . .** It's brand new, this Lindberg development . . . but, like all previous Lindberg developments, it's been blasting away old heating theories . . . not in one installation, not two, not ten, not fifty but in 97 *installations from coast to coast* made during the past year.

Like the Cyclone Tempering Furnace that preceded it 7 years ago . . . . like Tubulaire Heating Elements 5 years ago . . . . like Hydryzing at the '38 Metal Show in Detroit . . . this new Lindberg development has gone through the required Lindberg probationary period of 1 year under heavy, 24-hour a day production conditions. From the very first day of operation it has completely upset old heating theories.

**LINDBERG ENGINEERING COMPANY**
2448 WEST HUBBARD STREET, CHICAGO

Literature, photographs, and case histories are being prepared now. They will be ready February 1st.

WATCH THIS MAGAZINE FOR COMPLETE DETAILS

**LINDBERG FURNACES**

# UNCLE SAM CALLS FOR METAL

★ ★

The metal industry becomes the very heart of America's war efforts as Uncle Sam calls for more metal, for more guns and ships and planes and tanks.

This is a real job, this war. It means tremendous work for the metallurgical executives and engineers and production men who serve this industry. To do this work, they must have facts. They must be informed of every engineering development—and they must be informed promptly, concisely and authoritatively.

★ ★

We recognize this responsibility. Metallurgical engineering information is our job. The demands for doubled and quadrupled production will be the yardstick of our efforts to serve the 14,000 technical and non-technical men who look to us for metallurgical facts.

If you have a stake in this industry, if you sell the metal industry in ordinary times, or if you have something to contribute today, we invite you to participate in and benefit by the job this Society will do through the pages of Metal Progress.

★ ★

AMERICAN SOCIETY FOR METALS
and
METAL PROGRESS

7301 EUCLID AVENUE CLEVELAND, OHIO

# WIRE DRAWING*

By Kenneth B. Lewis

*IN WIRE* technology, as in other departments of human activity, the soundest basis on which to judge the future is the past. Past and present are as the rear sight and front sight of a rifle; project their line and you may judge where the shot will land. This, like all general rules, is subject to many apparent exceptions. The rear sight may be dim and ill-defined, the front sight may wobble, and it may be necessary to allow for considerable dispersal at the target, yet with all these disabilities the study of the history of an art is useful mental exercise......

[Here will only be quoted some of the pithy remarks of the lecturer, in the hope that the reader will be inspired to read the entire stimulating lecture.]

The genesis of the wire rod is implicit in its name. Anywhere but in the wire business a rod is a short, straight, relatively small bar. In the dawn of our craft the rod was a forged bar of wrought iron, about finger size and 8 to 10 ft. long.....This is a good place to comment on the metal. It is readily understandable that wire drawing, imposing upon the metal by its very nature the most drastic tests, should command the finest raw material, but it seems odd that these very remote ancestors of ours should have grasped so readily a principle which our contemporaries have not always conceded. I am putting this thought as delicately as I can .....

For over a century the rolling mill crept quietly into the industry, being constantly rebuffed, but always coming back. The rolling and collar-splitting of flats can safely be dated about 1700. One reliable date is 1728, at which time M. FLEUER of France made no secret of the fact that he was rolling rods in grooved rolls. This all went on, it is interesting to note, 55 years before HENRY CORT "originated" the use of grooved rolls. I shall have occasion from time to time to speak of the lawlessness of these early iron-masters, who never scrupled to make use of a process many years before it had been invented.....

Any assumption that the rod mill is to have a future, other

*(Continued on page 114)*

*Extracts from "The Shape of Things to Come", Mordica Memorial Lecture before the Wire Association, 1940, as published in *Wire and Wire Products*, January 1942, p. 15.

# CONTRIBUTORS TO THIS ISSUE

**Charles M. Lichy** was employed by Jones & Laughlin Steel Corp. in the metallurgical department immediately upon graduation from University of Pittsburgh in 1929 with a degree of B.S. in Chemical Engineering. He started as an inspector on the plate line at the 128-in. mill at the Soho plant and worked through various inspector and observer positions to general assistant metallurgist, Pittsburgh Works. In 1939 he was transferred to Detroit as metallurgical engineer on hot-rolled and cold-finished bars, and in September 1940 was promoted to assistant metallurgist, Pittsburgh Works.

**L. C. Grimshaw**, metallurgist at the Latrobe Electric Steel Co., was graduated from Rensselaer Polytechnic Institute, and studied metallurgy at Columbia University under the late William Campbell. He worked for two years in the metallurgical laboratories of the Ludlum Steel Co. before joining Latrobe in 1930. He was in charge of the pioneer development of the electrolytic method of producing clad steels, has written various technical papers and articles, and is the author of a chapter in the Metals Handbook.

**Ray P. Kells** joined the laboratories of the Latrobe Electric Steel Co. in 1923. After several years in the research department, he transferred to the metallurgical laboratories, where his present title is metallurgist in charge of heat treatment. Since 1935 his activities have consisted of research and sales engineering. With his wide experience in the handling and heat treatment of a large variety of toolsteels, Mr. Kells has contributed much to the successful handling of the molybdenum high speed steels.

A notable series of data sheets showing constituents of aluminum alloys first appeared in Metal Progress in 1933 emanating from **F. Keller** and co-workers at the Aluminum Research Laboratories. Development of metallographic technique has been Mr. Keller's field of research ever since he joined the Aluminum Co. of America in 1926, and a worthy supplement to the early series appears in this issue's data sheet and article concerning the 24S alloy. Mr. Keller was metallurgist for Aeromarine Plane and Motor Co. from 1917 to 1926. **R. A. Bossert,** his present co-author, has been working with him since 1929.

A note published in the September issue of Metal Progress concerning our good friend and long-time correspondent in France, **Albert M. Portevin,** mentioned that no issues of *La Revue de Métallurgie* had been received since April 1940. We now hear from Professor Portevin, on one of his infrequent trips to unoccupied France, that *Revue de Métallurgie* did not suspend publication. In the second half of 1940 it was issued only every two months, but monthly publication in Paris was resumed in 1941 although reduced in size because of paper shortage. Issues were not mailed, says he, because "it was not considered possible to send periodicals to the United States. Please convey my best wishes to all my American Friends."

*R. A. Bossert*

*C. M. Lichy*

*L. C. Grimshaw*

*R. P. Kells*

*F. Keller*

# WHAT'S NEW

## IN MANUFACTURERS' LITERATURE

### METAL WORKING

BLADES FOR INSERTED TOOTH milling cutters and lathe tools with full width tips, made of Tantung "G", are listed in two new bulletins issued by Vascoloy-Ramet Corp. Tantung "G" is a non-ferrous alloy containing tantalum carbide developed especially for borderline machining applications between the ranges of high-speed steel and cemented carbides. Bulletin Af-332.

"CUTTING FLUIDS" IS THE title of attractive new booklet published by Standard Oil Co. of New Jersey. Selection of cutting fluids, suggestions for handling them and a brief history of past and present practices in their use are presented. Bulletin Af-333.

CUTTING TOOLS. FIRTH-STERLing Steel Co. Bulletin Le-177.

METAL SAW. WELLS MFG. CO. Bulletin He-316.

HANDEE TOOL. CHICAGO Wheel & Mfg. Co. Bulletin Ie-230.

CONTOUR MACHINE. CONTInental Machines, Inc. Bulletin Ee-170.

HANDLING PROBLEMS. AMERIcan Monorail Co. Bulletin Ie-318.

CUTTING OILS. CITIES SERVICE Oil Co. Bulletin Ec-113.

HIGH PRODUCTION STAMPING machine. Chambersburg Engineering Co. Bulletin Gc-132.

CUTTING OIL HANDBOOK. D. A. Stuart Oil Co. Bulletin Ke-118.

HARDSTEEL DRILLS. BLACK Drill Co. Bulletin Ne-328.

1942 LINE OF THOR PORTABLE Electric Tools is described in an attractive new 64-page catalog just issued by the Independent Pneumatic Tool Co. This book is a helpful guide to the selection of proper equipment for various types of work. Bulletin Af-334.

PRESSES FOR POWDER METALlurgy are described in new and complete 48-page catalog issued by F. J. Stokes Machine Co. Valuable reference information is presented. Bulletin Af-335.

HOW PRESENT PRESSES CAN be adapted to new requirements is shown in two new bulletins published by the Denison Engineering Co. These bulletins are really shop tips that will be helpful to readers confronted with change-over operations. Bulletin Af-336.

KENNAMETAL STEEL CUTTING tool catalog. 32 pages by McKenna Metals Co. Bulletin Ke-238.

### FERROUS METALS

CARBON TOOL STEELS, THEIR heat treatment, range of applications and tool design, are described in a new 8-page booklet by Jessop Steel Co. Bulletin Af-173.

ENGINEERING AND TESTING laboratory data on "Five-Point" Deephard Steel are presented in a new bulletin published by Foote Bros. Gear & Machine Corp. Bulletin Af-244.

DESIGNING GREATER SALES appeal with stainless steel. 8-page booklet by Carpenter Steel Co. Bulletin Nc-12.

HARD FACING ALLOYS. WALL-Colmonoy Corp. Bulletin Kd-85.

FREE MACHINING STEELS. Monarch Steel Co. Bulletin Cd-255.

ALLOY STEELS. COPPERWELD Steel Co. Bulletin Ge-311.

TOOL STEELS. BETHLEHEM Steel Co. Bulletin Ce-76

DIE STEELS. LATROBE ELECtric Steel Co. Bulletin Ld-208.

STEEL DATA. VANADIUM-ALloys Steel Co. Bulletin Kd-294.

NITRALLOY DATA BOOK. NItralloy Corp. Bulletin Ke-116.

USES AND PROPERTIES OF molybdenum steels and irons. 125-page book by Molybdenum Corp. of America. Bulletin Ge-312.

NAX HIGH TENSILE LOW ALLOY steels. 20-page booklet by Great Lakes Steel Corp. Bulletin Kd-229.

NEWLY-REVISED AND EXlarged Graphitic Steel Booklet, issued by Steel & Tube Division, Timken Roller Bearing Co. Bulletin Ne-71.

PHYSICAL CHARACTERISTICS chart on the Elastuf group of machinery steels by Horace T. Potts Co., Brown-Wales Co., and Beals, McCarthy & Rogers. Bulletin Ed-264.

GOVERNMENT SPECIFICATIONS for carbon steels, a new chart by Peter A. Frasse & Co. Bulletin He-172.

INLAND STEEL CO.'S ENAMELing iron sheets are described in Bulletin Ld-295.

STAINLESS-CLAD STEEL IS COMprehensively described by Ingersoll Steel & Disc Div., Borg-Warner Corp. Bulletin Kc-253.

LOOSE-LEAF REFERENCE BOOK on molybdenum steels and their applications, by Climax Molybdenum Co. Bulletin Hb-4.

CRUCIBLE STEEL CO. OF AMERica describes three molybdenum grades of high speed steels in Bulletin Ge-56.

24-PAGE BOOKLET DESCRIBES molybdenum-tungsten high speed steels, by Cleveland Twist Drill Co. Bulletin De-103.

FIVE METALS FOR SPRING PURposes are described by International Nickel Co. Bulletin Ke-45.

### NON-FERROUS METALS

PLATINUM METAL CATALYSTS are discussed comprehensively in a new booklet just issued by Baker & Co., Inc. Bulletin Af-337.

COMPLETE LINE OF LEDALOYL, self-lubricating bearings are described in a new 36-page catalog published by the Johnson Bronze Co. This catalog will be particularly helpful to metallurgical men interested in design. Bulletin Af-237.

ALUMINUM CASTINGS. NATIONal Bronze & Aluminum Foundry Co. Bulletin De-307.

VARIOUS APPLICATIONS FOR the bearing metals and castings manufactured by National Bearing Metals Corp. are described in new Bulletin Af-338.

DOWMETAL DATA BOOK. DOW Chemical Co. Bulletin Ec-215.

**Use Handy Coupon on Page 110 for Ordering Helpful Literature. Other Manufacturers' Literature Listed on Pages 108 and 110.**

44-PAGE BOOKLET ON CCOPPER and copper alloys. Revere Copper & Brass Co. Bulletin Ke-239.

APPLICATIONS OF AMPCO Metal, an aluminum bronze alloy. Ampco Metal, Inc. Bulletin Ke-175.

ALUMINUM PISTONS AND CYLinder heads. Aluminum Co. of America. Bulletin De-54.

**WELDING**

AN ATTRACTIVE NEW 38-PAGE booklet describes Hobart Brothers Co. line of arc welders and accessories. Bulletin Af-20.

BRONZE WELDING. 16-PAGE booklet by Bridgeport Brass Co. Bulletin He-163.

NATIONAL CYLINDER GAS CO. has issued new circular describing features of the two-stage "Regolator" for producing a non-fluctuating welding flame. Bulletin Af-331.

50-PAGE PLASTIC BOUND BOOK showing products of Air Reduction Sales Co. Bulletin Le-69.

ELECTRODE QUANTITY AND welding time graph. Arcos Corp. Bulletin Ld-191.

NEW LOW TEMPERATURE WELDing alloys. Eutectic Welding Alloys, Inc. Bulletin Be-301.

THERMIT WELDING PROCESS and applications. Metal & Thermit Corp. Bulletin Ke-64.

OXY-ACETYLENE WELDING AND cutting equipment and processes. Linde Air Products Co. Bulletin Ge-63.

BRAZING ALLOYS. HANDY & Harman. Bulletin Ke-126.

BRAZING IN THE AJAX-HULTgren electric salt bath furnace. Ajax Electric Co. Bulletin Ke-43.

**TESTING & CONTROL**

FILM AND PLATE PROCESSING equipment for spectro analysis is described in new leaflet issued by Harry W. Dietert Co. Bulletin Af-198.

A NEW 8-PAGE FOLDER DIScussing the uses of gage blocks and optical flats has just been published by George Scherr Co. Bulletin Af-206.

HIGH TEMPERATURE FURnaces, control instruments and specialties for the laboratory. 32-page booklet by Burrell Technical Supply Co. Bulletin Ie-213.

MODERN POLISHING. TRACY C. Jarrett. Bulletin De-303.

OPTICAL AIDS. BAUSCH & LOMB Optical Co. Bulletin Ce-35.

PYROMETER CONTROLLER. Illinois Testing Laboratories, Inc. Bulletin Hb-180.

NEW CONDENSED CATALOG provides a convenient listing of the principal items of equipment manufactured by Wheelco Instruments Co. Bulletin Ee-110.

THERMOCOUPLE HEADS. CLAUD S. Gordon Co. Bulletin Be-53.

POCKET RELATIONSHIP TABLE. Wilson Mechanical Instrument Co. Bulletin Be-22.

NON-DESTRUCTIVE TESTING. Canadian Radium & Uranium Corp. Bulletin Ie-320.

METALLURGICAL EQUIPMENT. Adolph I. Buehler. Bulletin Ke-135.

TESTING EQUIPMENT. BALDwin Southwark Div., Baldwin Locomotive Wks. Bulletin Ne-67.

AUTOMATIC CONTROL. BROWN Instrument Co. Bulletin Ne-3.

PLATING TEMPERATURES. FOXboro Co. Bulletin Ne-21.

UNIVERSAL ENCLOSED TERMINal head. Arklay S. Richards Co. Bulletin Ne-330.

**HEAT TREATMENT**

"THE GREAT AMERICAN EMERgency" is the title of a beautiful new booklet by Surface Combustion Corp. describing the heat treatment of the outstanding items of ordnance production. Bulletin Af-51.

CAR BOTTOM, RECIRCULATING stress relief furnaces are illustrated and described in new leaflet by Mahr Manufacturing Co. Bulletin Af-5.

ECLIPSE GAS-FIRED FORGE furnaces are described in Eclipse Fuel Engineering Co. Bulletin Af-226.

20-PAGE BOOKLET ON RANAREX instruments for measurement of $CO_2$ in flue gases, with new text material on the control of furnace atmospheres. Permutit Co. Bulletin Af-339.

GENERAL ELECTRIC CO.'S NEW tool room furnaces are described in a new Bulletin Af-60.

VERTICAL FURNACE. SENTRY Co. Bulletin Ne-114.

INDUSTRIAL FURNACES. Drever Co. Bulletin Ke-321.

SALT BATH FURNACES. UPton Electric Furnace Co. Bulletin Ed-266.

ATMOSPHERE FURNACES. LITHium Corp. Bulletin Ie-319.

ARMAMENT FURNACES. LINDberg Engineering Co. Bulletin Le-66.

HEAT TREATING FURNACES. Holcroft & Co. Bulletin Ec-203.

CONVEYOR FURNACES. ELECtric Furnace Co. Bulletin Be-30.

INDUSTRIAL CARBURETORS. C. M. Kemp Mfg. Co. Bulletin Ce-219.

FURNACE CATALOG. AMERICAN Gas Furnace Co. Bulletin Be-11.

CONVECTED AIR FURNACE. DEspatch Oven Co. Nd-123.

ANNEALING FURNACE. CONTInental Industrial Engineers, Inc. Bulletin Nc-154.

TURBO-COMPRESSORS. SPENCER Turbine Co. Bulletin Da-70.

JOHNSON GAS APPLIANCE CO. catalog describes complete line of burners, furnaces, torches, mixers, valves and blowers. Bulletin He-298.

NEW ELECTRIC FURNACE. American Electric Furnace Co. Bulletin Gd-2.

FURNACE EXPERIENCE. FLINN & Dreffein Co. Bulletin Bc-82.

HIGH TEMPERATURE FANS. Michiana Products Corp. Bulletin Hb-81.

DEHUMIDIFIER. PITTSBURGH Lectrodryer Corp. Bulletin Bb-187.

CONVECTION FURNACES. HEVI Duty Electric Co. Bulletin Ke-44.

HEAT TREATING. LEEDS & Northrup Co. Bulletin Ke-46.

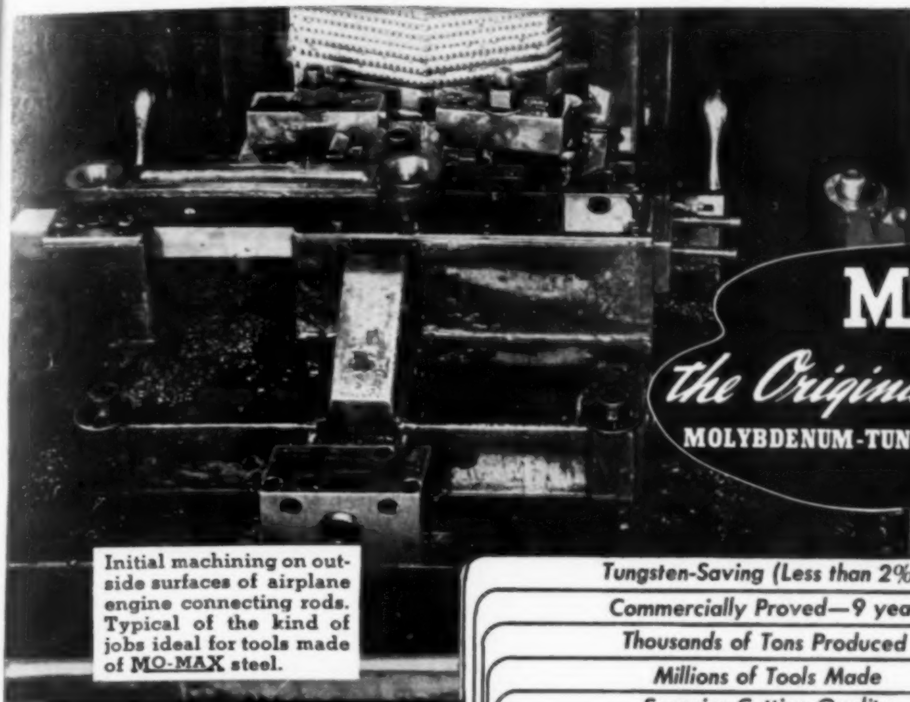
FURNACES. DEMPSEY INDUStrial Furnace Corp. Bulletin Ke-260.

TOCCO PROCESS OF INDUCTION Hardening. Ohio Crankshaft Co. Bulletin Lc-145.

LIQUID CARBURIZER. PARK Chemical Co. Bulletin Na-141.

BUTTERFLY VALVES FOR AIR, gas, steam and liquids. R-S Products Co. Bulletin Ke-234.

Use Handy Coupon on Page 110 for Ordering Helpful Literature. Other Manufacturers' Literature Listed on Pages 106 and 110.



CARBURIZING BOXES. PRESSED Steel Co. Bulletin Ce-269.

THERMONIC GENERATOR. Induction Heating Corp. Bulletin Ke-323.

WALL CHART OF HEAT TREATING information. Chicago Flexible Shaft Co. Bulletin Ne-49.

SHELL HARDENING. E. F. Houghton & Co. Bulletin Ne-38.

ELECTRIC FURNACES. HOSKINS Mfg. Co. Bulletin Hc-24.

## REFRACTORIES & INSULATION

NEW 24-PAGE BOOKLET LUMnite for refractory concrete showing use and applications. Atlas Lumnite Cement Co. Bulletin Af-340.

PLIBRICO JOINTLESS FIREbrick Co. has just issued booklet describing advantages and applications of new refractory material. Bulletin Af-341.

695 PLASTIC. BASIC REFRACtories, Inc. Bulletin Ke-192.

HIGH-ALUMINA BRICK. HARBIson-Walker Refractories Co. Bulletin Ke-324.

HEAVY DUTY REFRACTORIES. Norton Co. Bulletin Ie-88.

BONDING SILICA BRICK. Charles Taylor Sons Co. Bulletin Ge-218.

SUPER REFRACTORIES CATAlog. Carborundum Co. Bulletin Ld-57.

## FINISHING, PLATING, CLEANING

PROTECTIVE COATINGS, INC., has just published a comprehensive new catalog showing the Tocol line of protective coatings against corrosion, abrasion and rust. Bulletin Af-342.

CORONADO TAN—A NEW LUStreless synthetic enamel—and other U. S. Government finishes are described in new bulletins issued by Roxalin Flexible Finishes. Bulletin Af-343.

NEW CLEANING PROCESS. OAKite Products, Inc. Bulletin De-296.

ROCKER BARRELS. PANGBORN Corp. Bulletin Ae-68.

CADMIUM PLATING. E. I. duPont deNemours & Co., Inc. Bulletin Hd-29.

NEW, ILLUSTRATED FACTUAL folder has just been published by Alvey Ferguson Co., showing how various product washing problems were solved by this company. Bulletin Ne-329.

RUST PREVENTATIVE. ALOX Corp. Bulletin Nb-212.

ELECTROCHEMICAL DESCALING. Bullard-Dunn Process Div., Bullard Co. Bulletin Ge-143.

## MELTING, CASTING

TWO NEW BULLETINS DEscribe Fisher Furnace Co.'s wide range of stationary and tilting type crucible melting furnaces for ferrous and non-ferrous metals. Both will prove valuable additions to any foundryman's files. Bulletin Af-195.

FOUNDRY SAND. TITANIUM ALloy Mfg. Co. Bulletin Hc-90.

INGOT PRODUCTION. GATHmann Engineering Co. Bulletin Ka-13.

PIT HANDBOOK. AMSLER-MORton Co. Bulletin Kd-286.

COLUMBIUM. ELECTRO METALlurgical Co. Bulletin Cc-16.

ELECTRIC FURNACES. DETROIT Electric Furnace Div., Kuhlman Electric Co. Bulletin Hd-271.

## METAL ENGINEERING

NEW 16-PAGE BOOKLET PUBlished by American Manganese Steel Div., American Brake Shoe & Foundry Co., describes the basis for the design and alloy analysis of Amsco alloy heat treating containers and furnace parts and fixtures. Bulletin Af-9.

X-RAY INSPECTED CASTINGS. Electro Alloys Co. Bulletin Ld-32.

REFINERY ALLOYS. DURALOY Co. Bulletin Kd-233.

MEEHANITE CASTINGS. MEEHAnite Research Institute of America. Bulletin Ne-165.

STEEL CASTINGS. CHICAGO Steel Foundry Co. Bulletin He-184.

HEAT RESISTING ALLOYS. GENeral Alloys Co. Bulletin D-17.

PIPES AND TUBES. MICHIGAN Steel Casting Co. Bulletin Bb-84.

WIRE. CALLITE TUNGSTEN Corp. Bulletin Le-327.

IRON POWDERS. MORAINE Products Div., General Motors Corp. Bulletin Ke-322.

METAL POWDERS. METALS DISintegrating Co. Bulletin Ec-208a.

SPONGE IRON. EKSTRAND & Tholand, Inc. Bulletin Kb-202.

## GENERAL

NEW BULLETIN SHOWS HOW dust collectors contribute to modern industry and describes the self-contained units manufactured by the Torit Manufacturing Co. Bulletin Af-344.

A BIG, 48-PAGE CATALOG DEscribes the complete line of industrial products for efficient air control manufactured by A. Schrader's Son Div., Scovill Mfg. Co., Inc. Bulletin Af-326.

**Use This Coupon for Requesting Literature**

METAL PROGRESS
7301 Euclid Avenue
Cleveland, Ohio

Please send the bulletins which I have listed, by number, below.

Name ..........................................................

Title ..........................................................

Company ..........................................................

Company Address..........................................................

(Students should write direct to manufacturers for literature.)

Write numbers below.

# WHY WE USE COMMERCIAL HEAT TREATER

## "SPECIALIZED EQUIPMENT"

"One of our unusual jobs is an extra long bolt which needs straig
after treatment. Because a nearby commercial heat treater h
equipment for handling this job, we send it out to him. We also
specialized equipment for cyaniding, carburizing, etc. From an ec
standpoint it is more desirable to send this type of work to com
heat treaters."

W. C. Cook, Cleveland Cap Sc

## "JUST GOOD BUSINESS"

"We are specialists in our own field and feel that this keeps u
without trying to specialize in heat treating. Doing a job comp
to a commercial heat treater in our own plant would take too
equipment and man power. It is just good business for us to se
carburizing, flame hardening and other specialized heat treating job
nearby commercial heat treater."

W. F. Herman, Stahl Gear & Machi

## "GET VERY ACCURATE HEAT TREATMENT"

We do our own production annealing, normalizing, tool hardenin
production heat treating. At certain times we find it necessary t
our surplus to nearby commercial heat treaters. We also find it
sary to send certain repair machine parts and tools that are too l
be heat treated in our equipment. For this work we find the comm
heat treater indispensable.

C. A. Kelley, Atlas Bolt & Scr

# WIRE

*(Continued from page 102)*

than the quiet refinement of details which has characterized its recent past, pre-supposes that there is something wrong with rods now. That's right, there is. Rod quality is now the No. 1 bottleneck, as has lately been emphasized by the cutting off of Swedish rods from our market.....

What we want in a rod is uniformity, roundness, accurate size, and most of all an unblemished surface. The first three we get in increasingly satisfactory measure; it's the surface that worries the wire mill. When the surface is poor, the blemishes may be attributed to two congenital weaknesses of the present mill, namely, twist guides, and wear of the grooves....

As a trouble-shooter I have learned a couple of valuable lessons. One is that when trouble has been localized in a detail, or an operation, before trying to improve it consider whether you can eliminate it. The other is when you are definitely lost, go back to the last fork in the road and take the other branch. In the light of history, what should we do about rod defects?

The ancient Bedson mill with alternate horizontal and vertical rolls made no guide scratches because it had no twist guides. Its weakness, scale in the bearings, was a fault not of the designer but of the times. Vertical rolls are now a commonplace; why not go back to them, with sealed anti-friction bearings? We might well make all the stands 45° to the floor line, so that the alternate stands, right and left hand, would be duplicates. Individual motor drive would be a logical step.....

The sull coat is one of the few details whose history is clear and definite. Its origin is intensely interesting, though perhaps a bit tricky to explain in polite society; the sort of story that runs to rows of asterisks, quotation marks and foreign phrases.....

As to the future of the die, I refuse to stick out my neck. The making and preparation of dies used to belong to the wire drawer; it passed into the hands of the management; and now belongs to specialists from outside the organization — let them make the predictions.....

Taking the broad view, wire drawing remains absolutely unchanged after 1000 years. We have been simply pulling on one end of the wire; now we are asked to pull on both ends at once, with the promise of power saving, increased die life, reduction of friction, improvement of surface, and a more flexible control of physical properties . . .

SPENCER
HARTFORD

*Try these simple tests on any*

# SPENCER TURBO-COMPRESSOR

1. ***Vary the load***—Satisfactory operation without adjusting the blast gate.
2. ***Watch the ammeter.*** Power is used in proportion to the amount of air used. Efficiency is high at all loads.
3. ***Watch the pressure gauge.*** It is constant throughout the range from open to closed.
4. ***Balance a glass*** of water on top of the Turbo. Not even a ripple on the surface of the water!
5. ***Listen*** for mechanical or air noises. It is unusually quiet.
6. ***Examine*** a cross-section view. It is as simple as an electric fan, and built like a bridge.
7. ***Ask any man*** who has used a Spencer for ten or twenty years.
8. ***Ask your furnace*** or oven manufacturer. He is vitally interested in all-round performance.

**THE SPENCER TURBINE COMPANY, HARTFORD, CONN.**

# TURBO-COMPRESSORS

231-E

# LEAD

*(Continued from page 84)*

*Lead foil*, used for packaging, can ordinarily be replaced by such things as paraffined paper. Glass or other containers can be used for some materials now packaged in collapsible lead tubes. Restriction of lead foil and collapsible tubing at least to, and preferably below, the amount used in a normal year would force the use of other applicable methods of packaging.

The use of *white lead*, and other white pigments too, could be restricted in a severe emergency. Red lead could be restricted in some cases.

In the *building industry*, sheet-lead roofing could be substituted by other types, for instance, slate; other materials can be used for gutter linings and flashings and replaced with lead when the emergency is over.

It might be expected that *storage battery* connectors could be somewhat reduced in size. One expert feels that the storage battery industry should be able to get along with an appreciable reduction in the amount of lead per battery.

**Countervailing Increases**— Much of the recent increase in the use of lead has come from its substitution for copper, zinc and aluminum. Seldom is it an entirely satisfactory substitute in those uses where it has not hitherto been consistently employed. A lead-base die casting will not serve at all in many cases where zinc-base die castings are good engineering materials. Even its strongest alloys do not compare in strength with the alloys it is used to replace; so in replacements when strength is needed, a greater thickness of lead must be used. Thus the cost of the lead substitutes becomes high. Leaving aside the need for greater thickness in some cases, the cost of a given volume compares as follows:

| | Density | Cost, per Pound | Cost, per Volume |
|---|---|---|---|
| Lead | 11.34 | 5.85¢ | 66½ |
| Zinc | 7.14 | 8.25 | 59 |
| Copper | 8.94 | 12.00 | 107 |
| Aluminum | 2.70 | 15.00 | 42 |

Lower fabrication cost for the lower melting alloys of lead and of zinc somewhat modifies this comparison. Some authorities consider that the substitution of the stronger lead alloys in tubing and for flashings in place of copper is economical, even when not forced by scarcity of copper.

Since lead is so often used for permanence, as in underground piping and so on, replacement of a failure due to a substitute is costly. A suitable principle would be to restrict the use of lead in places easy to get at for repair, not to restrict its use in inaccessible locations.

# THE "COMING OF AGE" OF POWDER METALLURGY

*The dark feathers of a two-year-old eagle's head and tail are starting to change to the white of an adult bird. Photo by W. Bryant Tyrrell.*

AS AN ONLY METHOD of making parts with certain unique properties not otherwise attainable—powder metallurgy has had a place of special and growing importance for a quarter-century.

Now interest is intensified because powder metallurgy seems to be approaching "full stature" as an *alternative* method — a faster, cheaper way of making certain parts ordinarily fabricated by other established processes. One of the most appealing advantages today is that molding to finished dimensions (without scrap loss) can save machining time, and release valuable machine tools for other work.

Fabricators of powdered metal products are currently supplying a surprising number of different kinds of parts to industry. In articles of iron, brass, bronze, or other metals these manufacturers are enabling you to apply powder metallurgy's time-saving or cost-reducing advantages. If you are concerned with a problem of making small parts in large lots, quickly, powder metallurgy may have an answer.

You may be interested in addressing us. We have been producing powders of all metals for over a quarter-century, and have cooperated closely with leading manufacturers of powder metallurgy products.

METALS DISINTEGRATING COMPANY
MD
ELIZABETH NEW JERSEY

**METAL POWDERS SINCE 1916**

## COPPER STRIP

(Continued from page 53)

the degree of preferred orientation before rolling and on the magnitude of the reduction, is independent of the initial grain size. Some strip with certain types of structure, and particularly that having a small grain size before rolling, showed "self-annealing" effects after very heavy rolling reductions.

### Cold-Rolled Strip

*X-Ray Structure* — In the diffraction patterns on all four series cold rolled up to about 50% reduction, the sharp spots characteristic of fully annealed material have been replaced with radial streaks. This is taken to indicate that the initial deformation had occurred through the mechanism of slip. With progressively increasing cold rolling reductions the initial deformation by slip develops a preferred orientation of crystals. Partial and even complete recrystallization of the twin-fiber texture was found to have occurred in those samples with the smallest grain size, and which had been subjected to rolling reductions of about 90% and more.

*Microstructure* — Up to reductions of about 50%, the chief visible effects on the microstructure are an elongation of the crystals and a tendency for twin crystals to become oriented in the rolling direction. After reductions of more than 50%, striations transverse to the rolling direction, evidence of a second mechanism of deformation, appear across the crystals.

*Physical Properties* — Diamond pyramid hardnesses in some instances show a pronounced softening after high rolling reductions, particularly in the strip with the smallest grain size. This softening did not occur during rolling, but subsequently at room temperature — a "self-annealing" effect, which is related to the magnitude of the cold rolling reduction, the initial grain size of the material, and its original structure. The phenomenon is being further investigated. Evidence of this spontaneous annealing at room temperature was also provided by microscopic examination. Viewed normal to the strip surface, the fibrous, "stringy" appearance of the elongated grains is entirely absent, the groundmass appearing almost structureless.

The *N* strip shows, when tested in the soft condition, no evidence of directionality. With increasing rolling reductions the tensile strength assumes a definite maximum in the transverse

(Continued on page 130)

# COPPER STRIP

(*Continued from page 126*)

direction and a minimum value at 45° thereto.

In the *Db* strip in the soft condition the tensile strength is at a maximum in the rolling direction, the values in the other two directions being less than normal. Progressively increasing rolling reductions develop a maximum value for tensile strength in the transverse direction, and a minimum value at 45° to the direction of rolling.

The *Sb* strip showed the most pronounced directional differences of all four types considered. In the soft condition the tensile strength in all three directions (parallel, transverse and 45° to the direction of rolling) was much below the expected values for copper strip, and the highest value was in the 45° direction. Elongation was also at a minimum in this direction and, moreover, the value was much higher than normal, while in the other two directions it was much below. Increasing rolling reductions develop a maximum tensile strength in the transverse direction and a minimum value in the 45° direction.

The *Mb* strip, the structure of which is a combination of the *S* and *D* structures, showed a maximum tensile strength in the rolling direction and a maximum elongation in the 45° direction, features which are shown by strip in the soft condition and after a 10% rolling reduction. With increasing rolling reductions the same directional effect was developed as in the other series.

### Effect of Annealing

*X-Ray Structure* — Strip of the *N* series with rolling reductions up to 50% recrystallized on annealing with a random orientation of crystals. Above 50% there was, after annealing, an increasing degree of preferred orientation of the crystals in the strip. Two types of texture were developed — the double texture where the twin-fiber textures of the cold-rolled strips recrystallized independently, and the single texture where the twin textures had coalesced during the annealing.

Strips of the *D* series with lower rolling reductions showed, after annealing, a random orientation of the crystals. The presence before rolling of the double-texture structure does, however, influence the structure developed in the finally annealed strip. Strip with small grain size after a reduction of 80 to 95% developed a single-texture structure on annealing.

The *S* series after rolling and

(*Continued on page 134*)

# COPPER STRIP

(*Starts on page 53*)

annealing showed a predominance of the double-texture structure in the X-ray diffraction patterns, which is a notable feature in view of the fact that the single texture appears to be so stable on rolling.

The *M* series showed features of the other three.

*Microstructure* — Observations were made on the grain size of all four series with different rolling reductions followed by annealing at temperatures from 800 to 1800° F., at 200° intervals. Grain sizes varied from 0.1 mm. to 2 cm.

Rolling reductions up to 50% reduced the grain size. Large acicular crystals were usually found after rolling reductions of 90% or more, annealed at 1800° F., and in a structure with suitable proportions of crystals of both single and double-texture types. They were not found in any material which had originally the single-texture structure.

*Physical Properties* — Self-annealing can occur in material which possesses a relatively small grain size before rolling and which is rolled to such an extent that the twin-fiber textures recrystallize by coalescing to form the single texture. When crystals are reduced by cold rolling to thicknesses of about 0.003 mm. or less, they can no longer recrystallize independently; this thickness is, therefore, a critical dimension for copper at which the twin textures of cold-worked strip coalesce on annealing to form a single texture.

Waviness, or the formations of ears at 0° and 90° to the rolling direction, occurred when the structure contained an appreciable proportion of crystals of the single-texture type. Formation of ears at 45° to the direction of rolling was encountered with a structure wholly or mainly of the double-texture type, although many strips with this structure showed no ears.

To avoid directionality in finished annealed strip the final rolling reduction should not exceed 50%. If it exceeds 25% it is sufficient to eliminate on subsequent annealing any preferred orientation present in the strip before rolling. The final annealing temperature should not be higher than necessary to insure complete annealing. The temperature of the annealing operation before the last rolling stage influences the grain size, has a marked effect on the recrystallizing and annealing characteristics of the material after rolling, and also can exert a marked influence on directionality in the final strip when the subsequent rolling reduction is 50% or more.

## MAGNESIUM

(Continued from page 72)

the sheets were subsequently annealed. The effect, however, is not as serious as with cold rolled, unalloyed magnesium.

Cold work decreased the *reduction of area* in all directions of testing and 5% extension was decidedly harmful. Values were improved by annealing, but the discontinuity at 5% persisted. With severe cold deformation annealing at 750° F. improved the ductility. (Hot rolled sheets should not be annealed.) In the weaker directions comparatively small amounts of cold work decreased the reduction of area to about 4% — a value not increased by annealing.

Cold work of less than 10% extension decreased the figures for *elongation* but with 25 to 50% cold rolling, annealed at 550° F., elongation values were almost as good as those for hot rolled sheets. Annealing decreased the difference between the "strong" and the "weak" directions of sheets that had received a medium amount of cold work, but had little effect on sheets subjected to a greater degree of deformation.

*Hardness* increased with cold work up to 25% extension, after which it became a constant value related to the annealing temperature and not to the amount of cold work. Hot rolled sheets annealed at low temperatures were noticeably hardened.

The *grain size* was very much smaller than that of magnesium metal which had received exactly similar treatment. There is in this alloy no critical combination of cold work and annealing temperature that causes excessive grain growth accompanied by decreased mechanical properties, a phenomenon known to occur with many other materials. For all the amounts of cold work performed the temperature at which grain growth commenced and the temperature at which equiaxial grains were formed was practically the same — that is, 400 and 575° F. respectively.

**Extruded Slabs:** Under 50%, cold work had little effect on grain size of sheets rolled from extruded slabs, but annealing above 750° F. caused grain growth. Severer working produced large grains with low temperature annealing, and grain refinement when annealed above 575° F. The mechanical properties of sheets from cast slabs were equal, if not superior, to those from extruded sheets. Results of most of the tests on these two materials were similar, but sheets from cast slabs showed higher limits of proportionality. Annealing up to 575° F. caused some improvement in sheets rolled from cast slabs, but none on sheets rolled from the extruded slab.